# Hydrologic Conditions and Hazards In the Kennicott River Basin Wrangell-St. Elias National Park and Preserve, Alaska

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 96-4296

Prepared in cooperation with the
NATIONAL PARK SERVICE

Cover: Tram crossing West Fork Kennicott River during the outburst of Hidden Creek Lake, July 1995

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By Ronald L. Rickman and Danny S. Rosenkrans

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## CONVERSION FACTORS AND VERTICAL DATUM INFORMATION

| Multiply | by | To obtain |
|---|---|---|
| inch (in.) | 25.4 | millimeter |
| foot (ft) | 0.3048 | meter |
| mile (mi) | 1.609 | kilometer |
| square mile ($mi^2$) | 2.590 | square kilometer |
| cubic foot ($ft^3$) | 0.02832 | cubic meter |
| foot per hour (ft/hr) | 0.3048 | meter per hour |
| foot per day (ft/d) | 0.3048 | meter per day |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second |
| ton | 0.9072 | Megagram |

### VERTICAL DATUM

For this report, the U.S. Geological Survey vertical datum of 1908 was used. This datum is derived from USGS monument "K," established in 1908 with a stamped elevation of 1,414 ft above sea level. Monument "K" is located in the town of McCarthy.

### NOTE

In this report, "**Kennecott**" pertains to the mining company and mill site and "**Kennicott**" to geographic features. The rational for this dual spelling and usage is as follows: the mining company is named for Robert Kennicott, a pioneer surveyor; somehow, probably inadvertently, an "e" was substituted for the "i" in the company name. In 1908, the Post Office of "Kennecott" was established and continued until 1938. Present day map usage favors the original spelling honoring Robert Kennicott (Orth, 1967, p. 510).

### GLOSSARY

A glossary of technical terms used in this report starts on page 52. A term defined in the glossary appears in **bold** type at its first reference in the text.

# Hydrologic Conditions and Hazards in the Kennicott River Basin Wrangell-St. Elias National Park and Preserve, Alaska

By Ronald L. Rickman[1] and Danny S. Rosenkrans[2]


## Abstract

McCarthy, Alaska, is on the Kennicott River, about 1 mile from the terminus of Kennicott Glacier in the Wrangell-St. Elias National Park and Preserve. Most visitors to McCarthy and the park cross the West Fork Kennicott River using a hand-pulled tram and cross the East Fork Kennicott River on a temporary footbridge. Outburst floods from glacier-dammed lakes result in channel erosion, aggradation, and migration of the Kennicott River, which disrupt transportation links, destroy property, and threaten life. Hidden Creek Lake, the largest of six glacier-dammed lakes in the Kennicott River Basin, has annual outbursts that cause the largest floods on the Kennicott River. Outbursts from Hidden Creek Lake occur from early fall to mid-summer, and lake levels at the onset of the outbursts have declined between 1909 and 1995. Criteria for impending outbursts for Hidden Creek Lake include lake stage near or above 3,000 to 3,020 feet, stationary or declining lake stage, evidence of recent calving of large ice blocks from the ice margin, slush ice and small icebergs stranded on the lakeshore, and fresh fractures in the ice-margin region.

The lower Kennicott Glacier has thinned and retreated since about 1860. The East and West Fork Kennicott River channels migrated in response to changes in the lower Kennicott Glacier. The largest channel changes occur during outburst floods from Hidden Creek Lake, whereas channel changes from the other glacier-dammed lake outbursts are small. Each year, the West Fork Kennicott River conveys a larger percentage of the Kennicott Glacier drainage than it did the previous year.

Outburst floods on the Kennicott River cause the river stage to rise over a period of several hours. Smaller spike peaks have a very rapid stage rise. Potential flood magnitude was estimated by combining known maximum discharges from Hidden Creek Lake and Lake Erie outburst floods with a theoretical large regional flood. Flood hazard areas at the transportation corridor were delineated, and possible future geomorphological changes were hypothesized.


## INTRODUCTION

The town of McCarthy (fig. 1) is located in the largest national park system unit in the United States, Wrangell-St. Elias National Park and Preserve. The park contains some of the highest mountains in North America, many glaciers and ice fields, and abundant wildlife. More than 591,000 tons of copper ore was mined and processed in the McCarthy area between 1908 and 1938. Most of this copper came from Bonanza Ridge, 6 mi north of McCarthy and was transported to the coast by the Copper River and Northwestern Railway (CR&NWR). Railway bridges spanning the Kennicott River were commonly damaged or destroyed by floods and channel migration (McCarthy Weekly News, 1921-26; Janson, 1975; Friend, 1988). The railway ceased operations in 1938 and the railroad bed was gradually converted to the McCarthy Road.

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[1]U.S. Geological Survey, Anchorage, Alaska
[2]National Park Service, Copper Center, Alaska


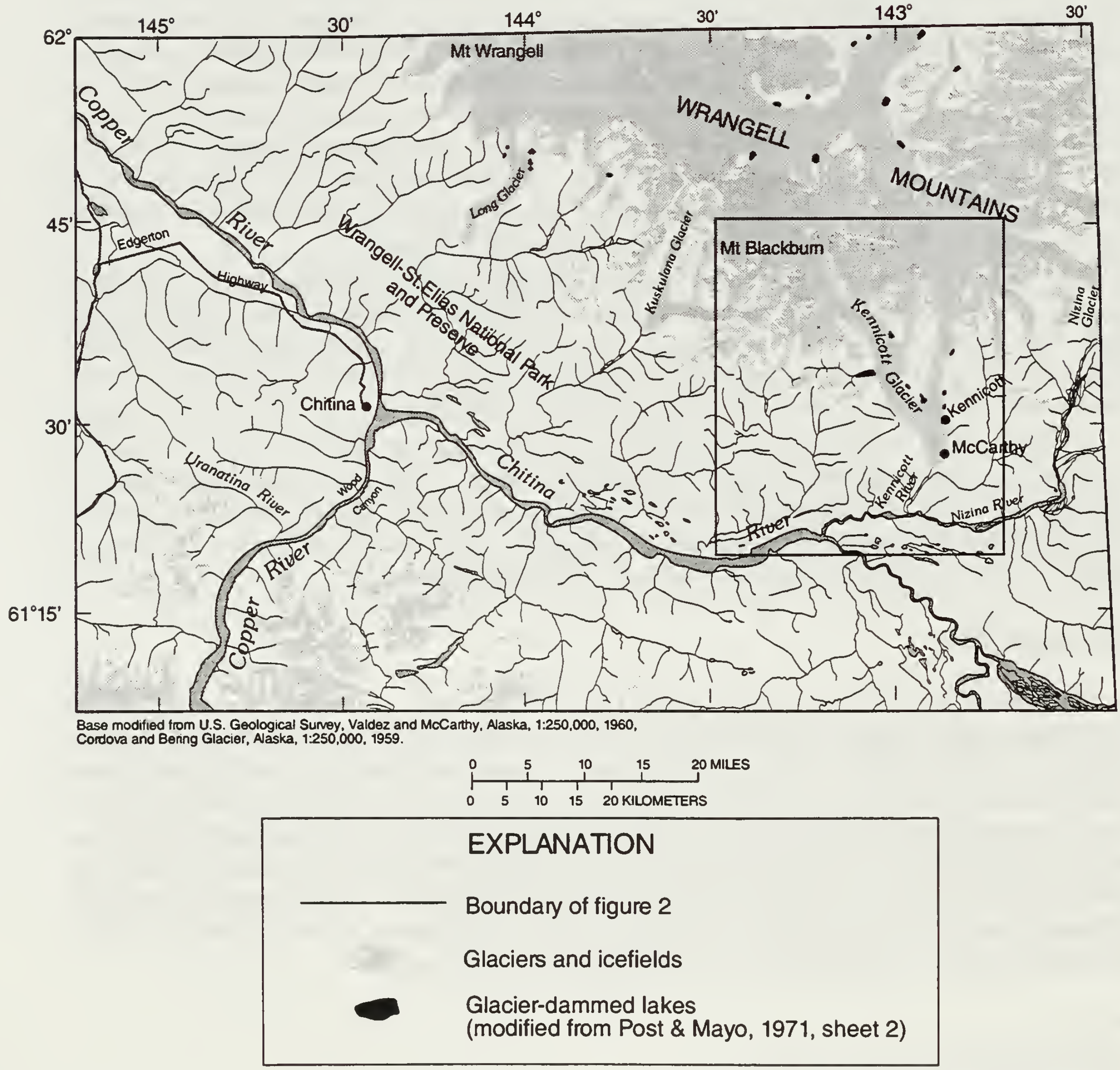


**Figure 1.** Location of Kennicott River Basin in Wrangell-St.Elias National Park and Preserve.

The rich colorful history and natural beauty of the McCarthy area attract several thousand visitors annually. Most of the visitors drive the McCarthy Road 59 mi from Chitina to the west side of the Kennicott River (fig. 2). The road ends at the river because bridges were destroyed in 1981 by catastrophic flooding caused by the Hidden Creek Lake outburst. Access to the Kennecott mines and the town of McCarthy requires visitors and residents to cross the West Fork Kennicott River in a hand-pulled tram suspended from a cable. A temporary footbridge has been constructed on the East Fork in addition to a hand-pulled tram. This bridge washes out on an annual basis. The hand-pulled trams and temporary bridge are scheduled to be replaced with permanent footbridges in 1997. A privately owned visitor parking and camping area is located on alluvial terraces near the tram crossing of the West Fork Kennicott River near the Kennicott Glacier terminus. The town of McCarthy (fig. 2) is also located on an alluvial terrace approximately 1 mi east of the visitor parking area.

Numerous glacier-dammed lakes are located in the Kennicott River Basin (fig. 2). **Outburst floods**[1] (jökulhlaups) are common in the Kennicott River and cause considerable loss of property, disruption of transportation links into Wrangell-St. Elias National Park and Preserve, and threaten human life. Flooding is the largest cause of river channel instability, channel migration, and channel rerouting. It is the policy of the National Park Service to preserve flood-plain values and minimize hazardous conditions associated with flooding. The U.S. Geological Survey (USGS), in cooperation with the National Park Service, evaluated hydrologic conditions and natural hazards in the Kennicott River Basin.

### Purpose and Scope

The purpose of this study was to identify, describe, and measure hydrologic conditions and hazards in the Kennicott River Basin that threaten park visitors, residents, and transportation routes in the park's most heavily used area. This report describes the results of the study; the study area is shown on figure 2.

The work included the following elements:

- Identify, map, and describe glacier-dammed lakes. Evaluate the timing and mechanism of outbursts, historical lake levels, and develop outburst predictive criteria for Hidden Creek Lake, which will provide warning of imminent flooding in the Kennicott River.
- Identify, map, and describe changes to Kennicott Glacier from 1909 to 1995, including internal drainage, glacier terminus changes, and outwash evolution to gain insight into probable and possible future changes in and around the transportation corridor.
- Describe the Kennicott River source, river stage, streamflow, channel erosion, aggradation, and migration.
- Evaluate hydrologic hazards for the West Fork Kennicott River and East Fork Kennicott River in and around the transportation corridor, determine whether specific hazards could be monitored in the future, and identify appropriate monitoring mechanisms. Other natural hazards, such as rockslides and snow avalanches were beyond the scope of this study.

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[1]**Bold** words defined in "Glossary"

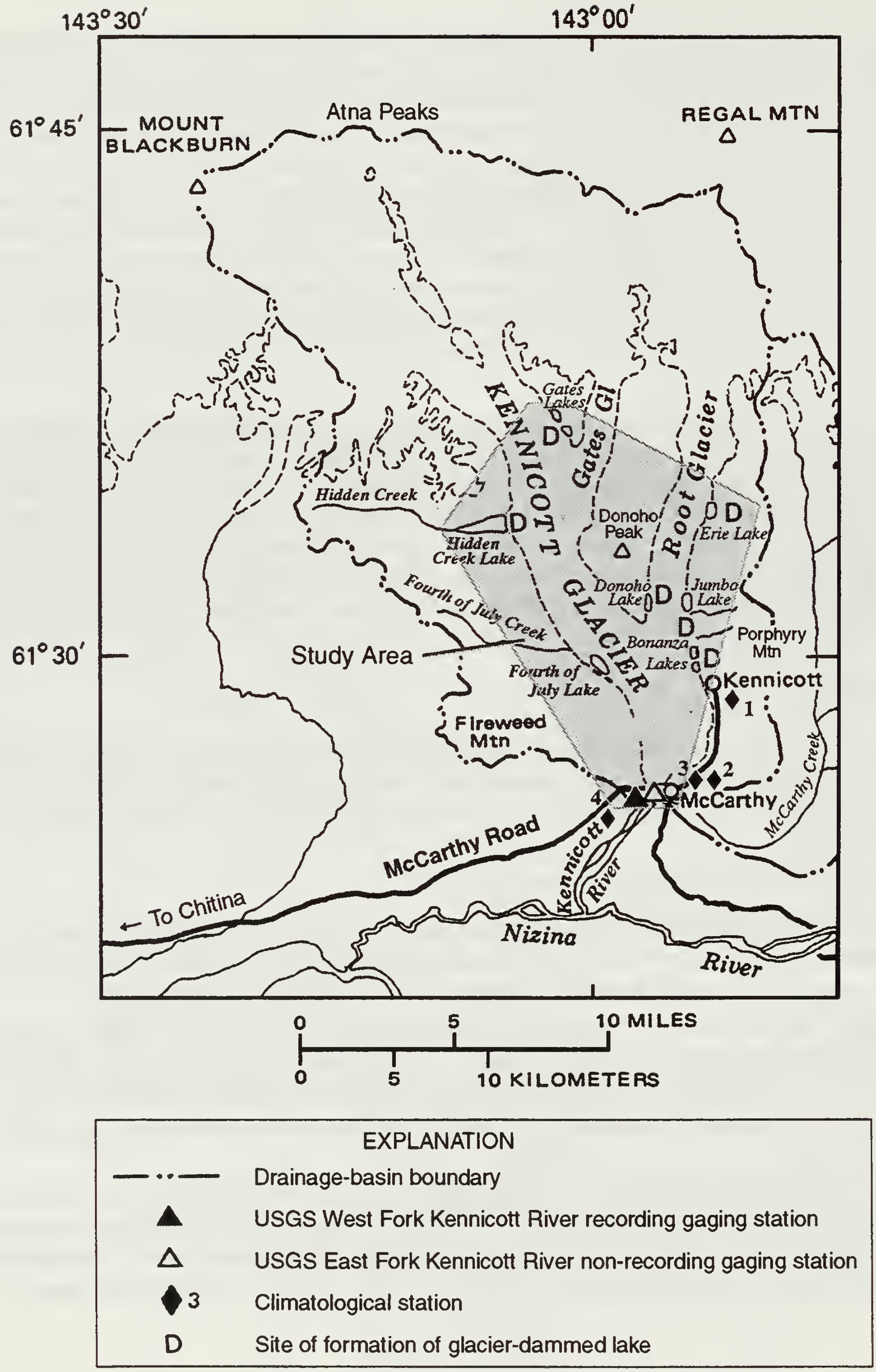



**Figure 2.** Location of study area, glacier-dammed lakes, and selected data-collection sites in the Kennicott River Basin.

## Acknowledgments

The assistance, cooperation, and information from the following residents of McCarthy are gratefully acknowledged. Edward LaChapelle, Professor Emeritus of Geophysics and Atmospheric Sciences, University of Washington, provided valuable field assistance, as well as historical and technical information regarding past flooding, flood damage, and glaciers. The Schrage family provided historical background of the tram area. Steve Siren allowed us to install and operate a stream-gaging station on his property. Kelly Bay provided valuable up-to-date information on the status of glacier-dammed lakes in the Kennicott Basin. Randy Elliot made field observations.

The assistance of the State of Alaska Department of Transportation and Public Facilities is appreciated. Donald Friend, Arizona State University, provided topographic information for Hidden Creek Lake as well as detailed eyewitness accounts of Hidden Creek Lake outburst flooding. Roger Elconin, Humboldt State University, provided valuable information concerning timing and interrelation of glacier-dammed lakes in the Kennicott Basin. Michael Martin, National Park Service, assisted with the 1995 surveys and data reduction. The assistance of Gary Smillie, National Park Service Water Resources Division is appreciated. Funding to support this project was provided by the National Park Service, Fort Collins, Colorado. Finally, we gratefully acknowledge the assistance of USGS personnel Timothy Brabets, Dennis Trabant, Chad Smith, Liska Snyder, Linda Harris, Joseph Walder, Carolyn Driedger, and Lynn Yehle.

# DESCRIPTION OF THE KENNICOTT DRAINAGE BASIN

## Climate

The Kennicott River Basin area (figs. 1 and 2) is located in a transitional climate zone between the wet, temperate climate of the coast and the drier climate with larger temperature extremes of the interior. Precipitation and surface-water runoff quantities vary because of the large elevation range and the presence of glaciers (Emery and others, 1985). Climate data have been collected at four climatological stations (Kennicott, McCarthy, McCarthy 1 NE, and McCarthy 3 SW; fig. 2, and table 1). Currently, climatological data collected at McCarthy 3 SW, about 3 mi southwest of McCarthy, are published monthly by the National Oceanic and Atmospheric Administration (1922-90) and are summarized intermittently by the Arctic Environmental Information and Data Center (Leslie, 1989). Precipitation data for additional sites in and near the Wrangell- St. Elias National Park have been summarized by Jones and Glass (1993).

**Table 1.** Precipitation at selected climatological stations in the Kennicott River Basin near McCarthy
[Data from National Weather Service (National Oceanic and Atmospheric Administration, 1922-90)]

| Site No. (fig. 2) | Station name | Latitude | Longitude | Elevation (feet) | Period of record | Mean annual precipi-ation (inches) | Maximum daily rainfall[1] (inches) |
|---|---|---|---|---|---|---|---|
| 1 | Kennicott | 61° 29' | 142° 53' | 2,210 | 1/22-8/47 | 23.26 | 1.97 |
| 2 | McCarthy 1 NE | 61° 26' | 142° 54' | 1,540 | 10/76-2/83 | 20.82 | 2.00 |
| 3 | McCarthy | 61° 26' | 142° 55' | 1,380 | 7/68-9/76 | 17.23 | 1.13 |
| 4 | McCarthy 3 SW | 61° 25' | 143° 00' | 1,250 | 1/84-10/90 | 21.47 | 2.33 |

[1]For months May through September

Recorded values of annual precipitation range from 10.11 in. at McCarthy during 1969 to 30.68 in. at Kennicott in 1944. According to the generalized mean annual precipitation map of the Copper River basin (Jones and Fahl, 1994), mountainous areas above the precipitation collection sites shown in table 1 receive from 40 to more than 80 in.

## Physical Description

The Kennicott River originates on the south side of the Wrangell Mountains and terminates at the confluence with the Nizina River (fig. 2). The basin upstream from the confluence with McCarthy Creek is 352 $mi^2$ in size, of which approximately 46 percent is covered by glaciers and perennial snow. Several peaks in the Kennicott River Basin are higher than 13,000 ft: Mount Blackburn is the highest at an elevation of 16,390 ft. Bedrock of the upper basin includes andesitic flows and pyroclastics of the Wrangell volcanic field, and intrusive rocks which include **dacite** (MacKevett, 1972). Bedrock in the Hidden Creek Valley and lower reaches of the Kennicott River valley is made up of predominately the Chitistone Limestone, Nizina Limestone, Nikolai Greenstone, all of Triassic age, and of the McCarthy Formation of Triassic and Jurassic age (MacKevett, 1972).

### Glaciers

The largest glacier in the basin is Kennicott Glacier (fig. 2), which is 28 mi long and drains the south side of Atna Peaks and the southeast side of Mount Blackburn. Root Glacier (fig. 2), a tributary to Kennicott Glacier, is the second largest glacier in the basin. This glacier is 17 mi long, drains the south side of Regal Mountain, and merges with Kennicott Glacier immediately south of Donoho Peak.

Kennicott Glacier has been described by Bateman (1922), Field (1975), Denton (1975), and Jones and Glass (1993). Drawings and descriptions by Bateman, as well as aerial photographs from the last 60 years, indicate that the lower part of Kennicott Glacier has thinned and retreated. An ice-cored moraine at the glacier terminus has thawed. Botanical observations at the terminal moraine indicate that the maximum advance occurred about 1860 (Viereck, 1967). A 360-year-old group of trees, partly buried by alluvial deposits, indicates that the glacier has not extended beyond its 1860 maximum since at least 1600 (Viereck, 1967).

Glaciers in the Wrangell Mountains commonly block ice-free tributary valleys, forming unstable lakes. Many glacier-dammed lakes drain rapidly on an annual basis. Failures of the glacier-ice dams cause periodic flooding downstream. Two glacier-dammed lakes are found along Kennicott Glacier and four along Root Glacier; numerous **supraglacial** lakes are found on both glaciers. The largest glacier-dammed lake is Hidden Creek Lake, located on the west flank of Kennicott Glacier (fig. 2).

### Kennicott River

The Kennicott River flows from the terminus of Kennicott Glacier 4.7 mi to the confluence with the Nizina River. Two channels currently flow from the terminus of the glacier. The West Fork Kennicott River is the larger channel, located on the western side of a terminal **moraine** and the smaller East Fork Kennicott River is on the eastern side. A capture channel at the toe of the Kennicott Glacier terminus currently diverts much of the flow from the East Fork Kennicott River into the West Fork Kennicott River. Mean annual discharge for the combined flow of the East and West Forks Kennicott River at McCarthy is estimated to be about 1,300 $ft^3/s$ (Jones and Glass, 1993).

## HYDROLOGIC CONDITIONS

### Glacier-Dammed Lakes

Six glacier-dammed lakes and numerous small ponds that drain periodically are known in the Kennicott basin (fig. 2). In this report, Bonanza Lakes are considered a single lake, as are Gates Lakes. Physical characteristics of the larger lakes are summarized in table 2 and described below.

**Table 2.** Selected physical characteristics of glacier-dammed lakes in the Kennicott Basin

| Lake name (fig. 2) | Distance up-glacier from McCarthy (miles) | Surface elevation[1] (feet) (USGS 1908 datum) | Estimated depth[1] (feet) | Approximate surface area[1] (square miles) |
|---|---|---|---|---|
| Hidden Creek | 10 | 3,000 | 350 | 0.5- 0.75 |
| Erie | 9 | 3,000 | >100 | 0.12 |
| Donoho | 6 | 2,500 | >100 | 0.03 |
| Gates | 12 | 3,400 | Unknown | 0.012-0.015 |
| Jumbo | 5 | 2,100 | 50-75 | 0.02 |
| Bonanza | 3.8 | 2,000 | 75-100 | 0.008-0.013 |

[1]At maximum observed lake stage

Three other small lakes perched in the lateral moraines near Fourth of July Creek, Donoho Peak, and upper Kennicott Glacier did not drain during the study, and appear to be isolated from the active glacial system.

#### Hidden Creek Lake

Hidden Creek Lake is the largest glacier-dammed lake in the Kennicott basin and is located approximately 10 mi northwest of McCarthy (fig. 2). The lake abuts the western margin of Kennicott Glacier (fig. 3). Melt from glaciers, rock-glacier ice, and snow, as well as rainfall and ground water, contribute to lake inflow. The lake is at an elevation of approximately 3,000 ft and has a surface area ranging from 0.5 to 0.75 $mi^2$ when full. Historical records reveal that Hidden Creek Lake (originally called Icy Lake) has had outbursts since at least the turn of the century (Moffit, 1938). The lake was first described in 1907 (Moffit and Maddren, 1909) and the earliest reported outburst was in 1909 (Moffit and Capps, 1911).

Hidden Creek Lake is located adjacent to the Kennicott Glacier **ablation** zone. Kennicott Glacier has retreated since its 1860 maximum, leaving conspicuous terminal lateral moraines. Currently, lateral moraines near the terminus are situated approximately 100 ft above the adjacent glacier ice surface indicating substantial loss of glacial mass since 1860. The 1957 and 1994 ice-margin positions have retreated approximately 750 and 1,100 ft, respectively, from the 1860 moraine (fig. 3). Retreat is most extensive along the southeast corner of the lake, near the drain hole. The western lake boundary at maximum stage has migrated downvalley over time, concurrently with retreat of the ice margin in the lake basin.

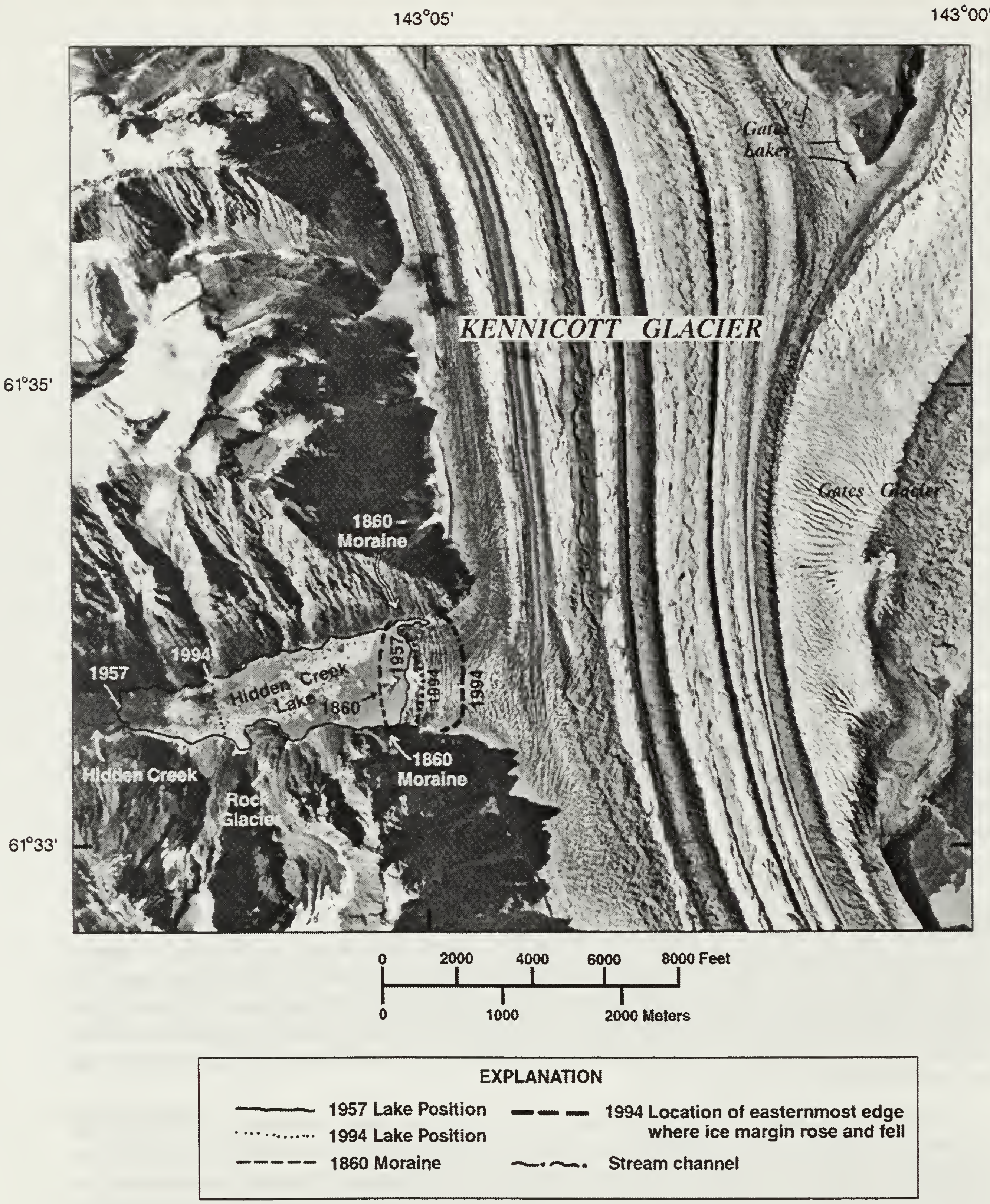



**Figure 3.** Maximum stage and glacier margin position for selected years at Hidden Creek Lake (U.S. Geological Survey, July 29, 1957 aerial photograph.)

### Ice Dam and Outbursts

Observations during the study show that glacier ice adjacent to Hidden Creek Lake floats as the lake fills and settles as the lake drains. Time-lapse photography obtained during the summers of 1994 and 1995 recorded the collapse of the Kennicott Glacier margin during the outbursts. Retreat of the ice margin is fastest when it is floating. One week prior to the 1994 outburst, large icebergs calved from the ice margin. The 1957 aerial photograph (fig. 3), taken 5 days prior to the outburst, shows a large iceberg in front of the ice dam. Calving of large icebergs may signal floating of the ice margin and water leaking through the ice dam.

A series of **arcuate** crevasses develop across the glacier where it pushes into Hidden Creek Valley (fig. 3). These crevasses mark the zones of vertical and horizontal displacement along which the ice margin rises and falls. They extend 1,200 ft back from the ice margin, indicating that the ice floats over a wide zone. Direct measurement of ice-margin lifting was not possible, but scaling of features indicates that the margin rises 75 ft or more as lake level rises.

Thickness of the glacier dam is a factor controlling maximum lake stage. When lake stage reaches approximately nine-tenths the ice thickness at the damming point, the ice floats, thus allowing the lake to drain (Post and Mayo, 1971). The lake is approximately 350 ft deep adjacent to Kennicott Glacier (Friend, 1988). Depth soundings along the glacier were not practical because of safety concerns. Lack of historical and current glacier thickness data prevents reconstruction of glacier thickness in the ice-dam region. Continued decreasing glacier thickness and retreat of the ice margin are reducing the effectiveness of the ice dam to impound water.

### Timing and Mechanism of Outbursts

Historically, Hidden Creek Lake has drained annually during the late summer or early fall. There have been no reported winter outbursts. A complete list of known lake conditions from 1860 to 1995 is presented in appendix 1. On the basis of 25 known outburst dates between 1911 and 1995 (fig. 4), Hidden Creek Lake has shown a trend toward earlier outburst dates. During years in which the date of the outburst was not recorded, the approximate time of outburst can be deduced from observations before and after the outburst had occurred (fig. 5). Trends between 1970 and 1995 are less obvious: all outbursts occurred between early July and mid-August. Since 1988, Hidden Creek Lake has drained annually between July 5 and August 3.

Survey monuments were established at several locations in and around the Hidden Creek Lake basin. Monument locations and elevations were tied to a common datum using the Global Positioning System (GPS). Information about monument locations, elevations, and survey error can be found in appendix 2. Historical lake elevations were determined by surveying matching points from historical photographs with points on the ground (appendix 3). Whenever possible, several points around the lake perimeter were surveyed for each photograph to verify the maximum elevations. A list of the photographs used is found in appendix 1.

**Dropstones** found in the alluvial fan zone were surveyed. The uppermost limit of lake deposits (thickness increases down valley) is slightly higher than the 1957 lake level (3,083 and 3,071 ft, respectively). Isolated dropstones protrude through or rest upon the recent alluvium up to 3,101 ft elevation, which corresponds closely to the surveyed maximum stage for 1916. Remnants of a very old washline follow the 3,152-foot-elevation contour. This washline is the highest known water level and is thought to have formed about 1860 during the little ice age. Maximum lake elevation

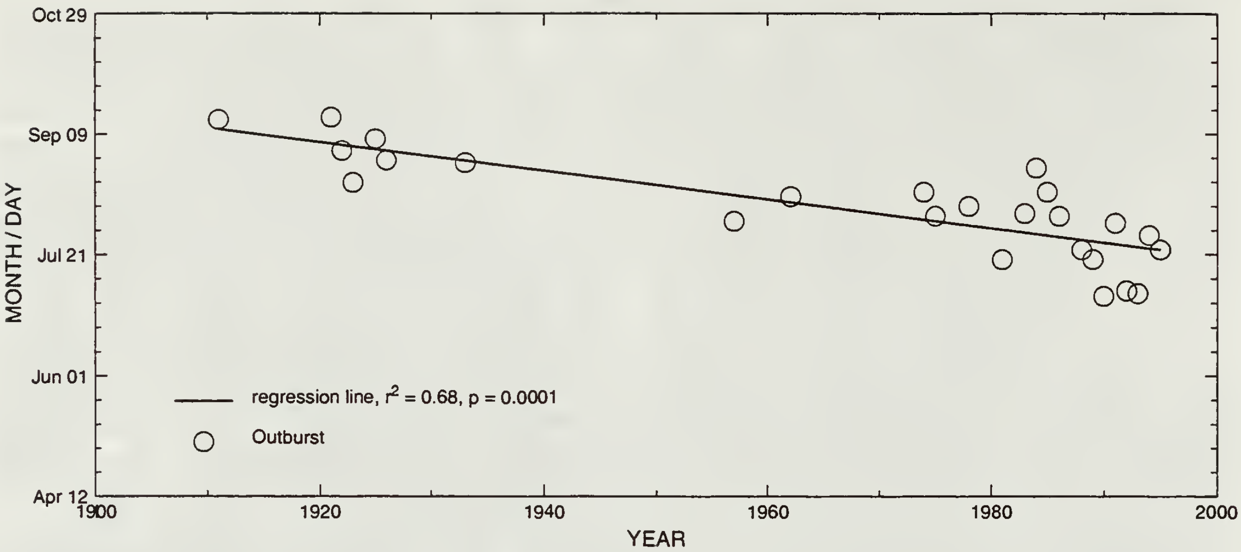



**Figure 4.** Known and reported outburst dates for Hidden Creek Lake, 1911 to 1995.

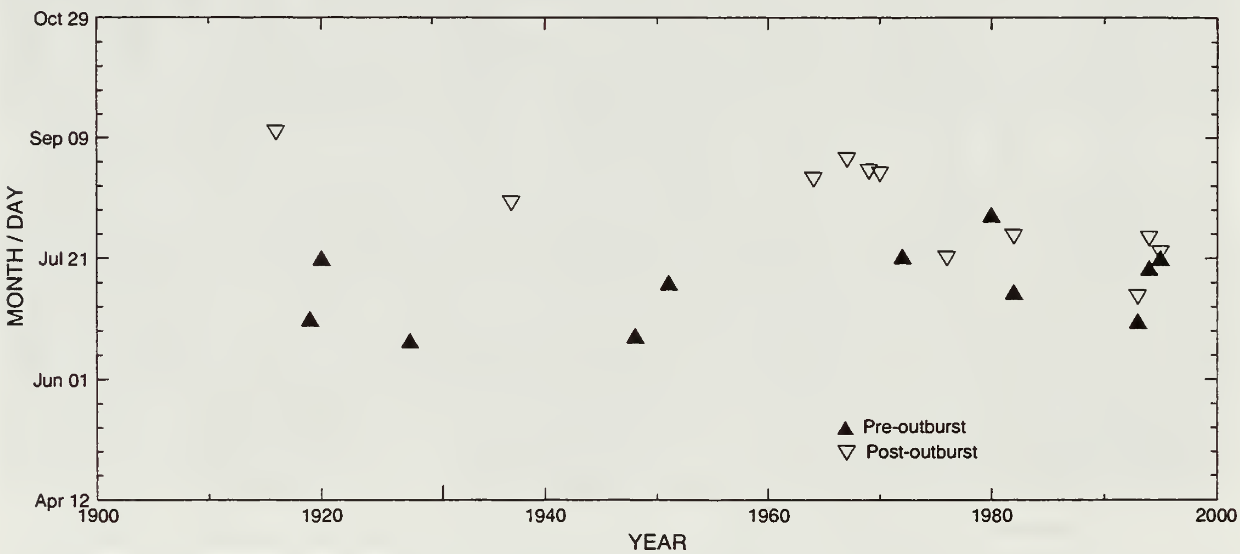



**Figure 5.** Known pre- and post-outburst dates for Hidden Creek Lake, 1911 to 1995.

data for 1860 to 1995 show a decreasing trend with time (fig. 6). Maximum lake stages, 1990 to present, have been between 3,000 and 3,020 ft and are significantly lower than pre-1957 stages (fig. 6). The 1992, 1994, and 1995 lake levels reached 3,002, 3,021, and 3,007 ft, respectively.

The combination of increasingly early outbursts and lower lake levels prior to outburst are probably caused by thinning of the Kennicott Glacier at the dam. Ice deformation and ice/bed separation caused by glacier movement may also play a role in the outburst timing. Determining the outburst mechanism is beyond the scope of this study. Outburst mechanisms for glacier-dammed lakes are discussed more thoroughly by Embleton and King (1975, p. 540-41) and Knight and Tweed (1991, p. 175-184).

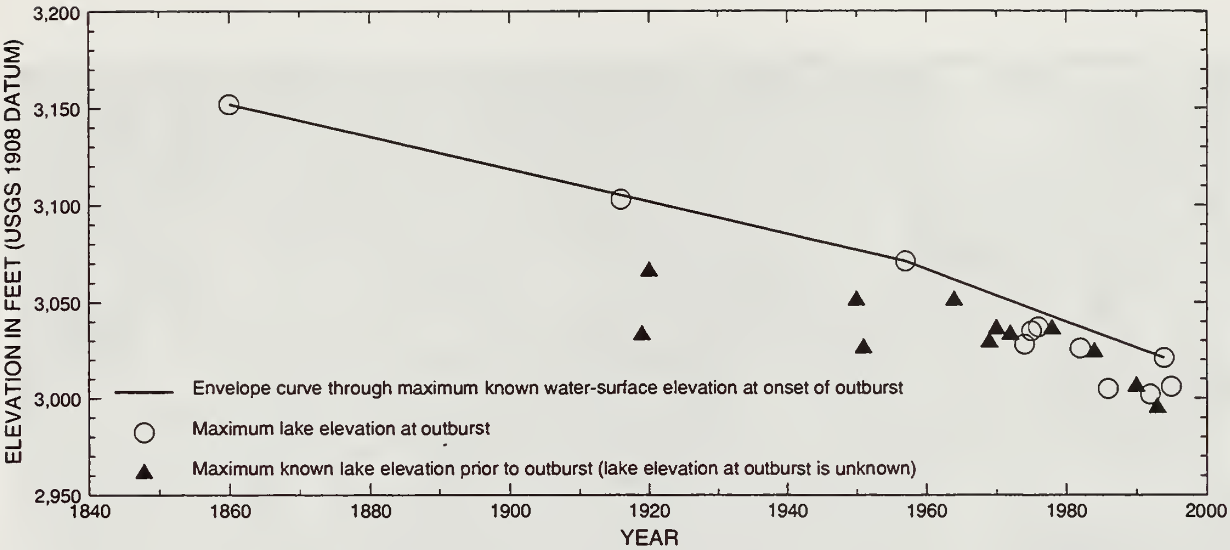



**Figure 6.** Maximum known water-surface elevations at onset and prior to outbursts for Hidden Creek Lake.

After the lake drains, Hidden Creek traverses the former lakebed and flows under Kennicott Glacier at the southeast corner of the former lake basin in what appears to be the remnants of a large drainage cavern. Glacier-dammed lake drainage conduits reseal by **plastic deformation** and collapse of glacial ice (Embleton and King, 1975, p. 340).

### Hidden Creek Lake Bed

The Hidden Creek Lake bed can be divided into three distinct zones: *alluvial fan*, *ice-cored*, and *depression* (fig. 7).

The *alluvial fan zone* is an active alluvial fan filling the valley bottom. The 2 percent bed slope is incised by Hidden Creek. A thin glacial-lake dropstone veneer overlies fluvial deposits (fig. 8). Greenstone and limestone constitute most of the fluvial gravel, and make up all of the rock outcrops in Hidden Creek Valley.

The *ice-cored zone* is the area between the 1860 side-valley moraine and a rock glacier, and is incised by several small streams (figs. 3 and 7). Ice is exposed in the incised streambanks of Hidden Creek. Large blocks of ice remain attached to the substrate and do not float when covered by lake water. Part of the lake bottom is probably an ice-cored down-slope extension of the upper alluvial fan zone, but has been lowered because of melting of the ice core. The ice core is overlaid with well-rounded gravel, similar to that found in the alluvial fan zone.

The *depression zone* is an oval-shaped depression between the 1860 moraine and the ice dam (figs. 7 and 9). It is covered and choked with large icebergs after the lake drains. This large depression was formed after Kennicott Glacier retreated from its side-valley moraine. Depression depth may exceed 350 ft near the ice dam, and contains a significant portion of the total lake volume (Friend, 1988). A small lake that was formed when the photograph was taken is shown in figure 9. This small lake had drained by the next morning, and began re-forming.

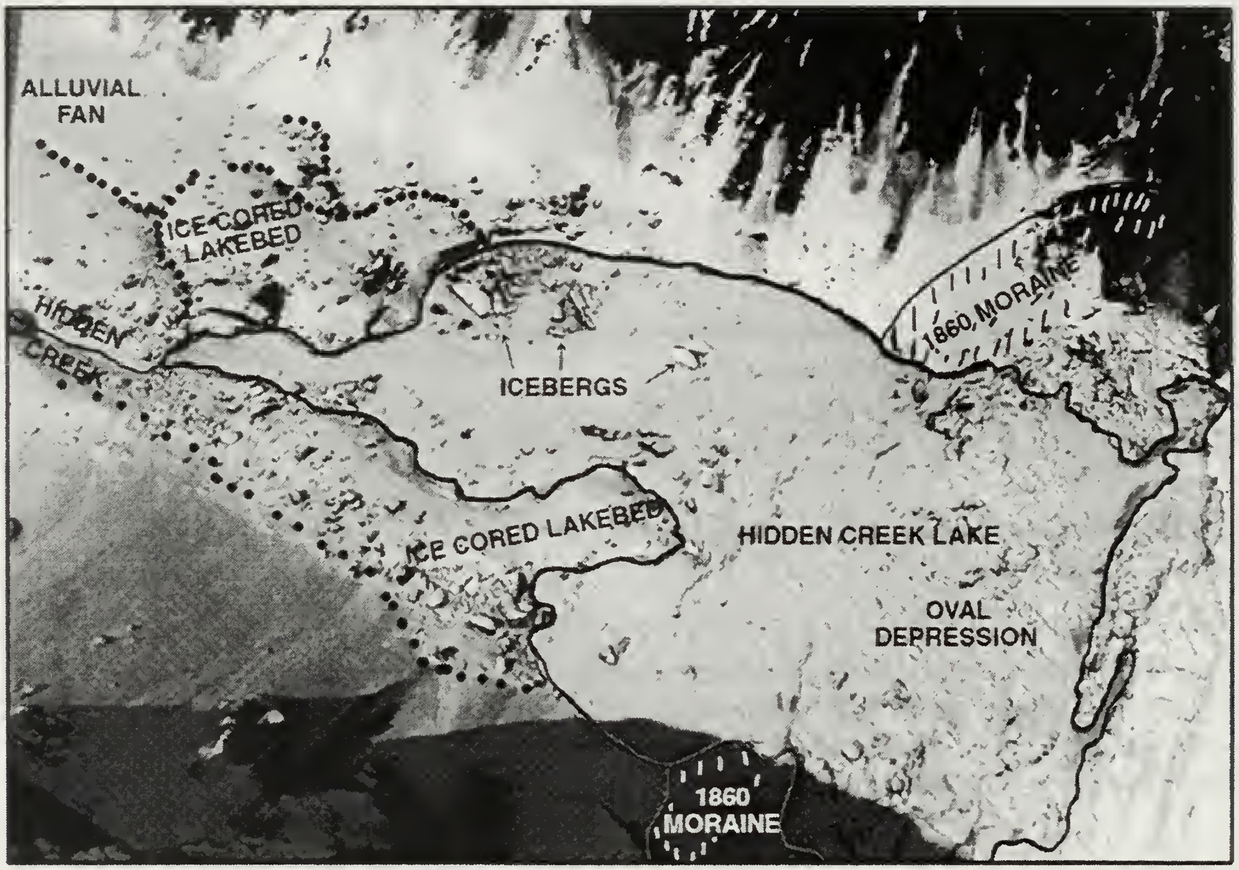



**Figure 7.** Alluvial-fan, ice-cored, and depression zones of Hidden Creek Lake bed, May 12, 1994.

### Lake Volume and Stages, 1994 and 1995

A lake stage-volume curve was developed by plotting 1994 and 1995 Hidden Creek Lake survey data (fig. 10; appendix 3). Volumes for the surveyed part of the lakebed were calculated using Geographic Information System (GIS) software. Much of the lakebed was choked with icebergs and was not surveyed. Volume was adjusted to include the oval depression at the ice dam, using data from Friend (1988). The approximate change in lake volume with elevation is shown in figure 10. However, this illustration does not reflect total volume of water retained because the volume beneath the ice wedge between the ice margin and the dam, and within glacier fractures cannot be measured.

Lake level rose approximately 2 ft/d between July 1 and July 9, 1994 (Joseph Walder, USGS, written commun., 1995). Lake levels were observed to become stationary or slowly drop prior to the 1986 outburst (Friend, 1988). This was also documented using time-lapse photography for the 1994 and 1995 outbursts. Slow declines in lake stage up to 6 days prior to outburst were not noticeable from aerial observations made in 1994 and 1995.

**Figure 8.** Hidden Creek Lake bed deposits capping fluvial gravels, August 31, 1994.

#### Criteria for Pending Outbursts

The following criteria indicate when an outburst of Hidden Creek Lake is imminent:

- Lake stage near or above the level of recent maximum stages (3,000 to 3,020 ft).
- Stationary or declining lake stage during the period in which meltwater and rain would be expected to be raising the lake stage (July and August).
- Evidence of recent calving of large ice blocks from the ice margin.
- Formation of a "clean ice" washline along the ice margin. This is visible after a small decline in lake stage.
- Slush ice and small icebergs stranded on the lakeshore.
- Fresh fractures and escarpments in the ice margin region.

**Figure 9.** Large depression near the glacier margin, Hidden Creek Lake, August 31, 1994.

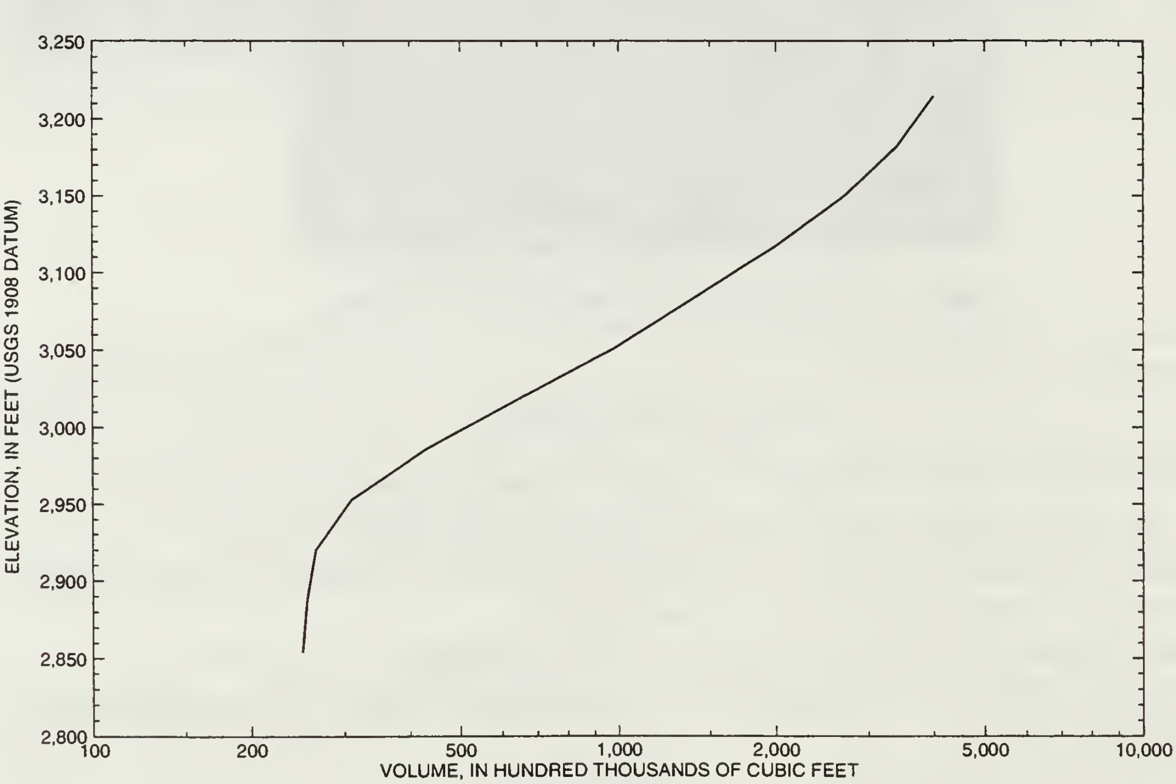



**Figure 10.** Hidden Creek Lake volume (based on 1994 and 1995 survey data; not adjusted to exclude volume displaced by icebergs)

### Other Glacier-Dammed Lakes

Erie Lake is the second largest glacier-dammed lake in the Kennicott basin (fig. 2, table 2). **Strandlines** indicate that recent maximum lake stages are lower than historical lake levels (fig. 11). The lake usually outbursts during July or early August, based on observations made in 1982, 1988, and 1993-95. The Erie Lake outburst occurred before the Hidden Creek Lake outburst in 1994, and after the Hidden Creek Lake outburst in 1995. Erie Lake drained in 3 days during the 1994 outburst. One of the **englacial** or **subglacial** conduits, observed during the 1994 outburst, is located at the up-glacier end of the lake, indicating a complex drainage system (Roger Elconin, Humboldt State University, written commun., 1994). A compilation of Erie Lake fill and drain information can be found in appendix 4.

Donoho Lake is located at the confluence of the Root and Kennicott Glaciers (fig. 2). Its main source of inflow is a small creek (fig. 12) that drains non-glacier lakes below Donoho Peak, as well as snowmelt and glacier icemelt from the surrounding glaciers. During 1994, the lake drained in early June after Jumbo Lake drained, and prior to Erie and Hidden Creek Lake outbursts. Unidentified englacial and (or) subglacial sources, as well as rain and glacier meltwater, refill the lake periodically after the initial early summer outburst. As Hidden Creek Lake drains, Donoho Lake refills with muddy water and remains full until Hidden Creek Lake is empty, at which time Donoho Lake also drains. Muddy water refilling this lake is a good indicator that the Hidden Creek Lake outburst has begun. A summary of historical data and references for Donoho Lake can be found in appendix 4.

Since 1948, two or three small lakes, referred to as Gates Lakes, have formed near the confluence of the Gates and Kennicott Glaciers (fig. 2). These are usually the last glacier-dammed lakes in the Kennicott basin to drain; however, monitoring in 1994 revealed small declines in water level in July. They did not drain until late fall.

Jumbo Lake is adjacent to Root Glacier between Erie Lake and Bonanza Lakes (fig. 2). Amazon Creek, Jumbo Creek glacier meltwater, and rainwater all contribute to Jumbo Lake. Historical records show that the lake is empty during July and August (appendix 4). The lake slowly drained over a 6-day period between May 20 and May 26 during 1994. This lake is connected to the internal drainage system of Root and Kennicott Glaciers: it refills when Hidden Creek Lake drains. Jumbo Lake prior to draining in 1994 is shown in figure 13.

Bonanza Lakes consist of two small ponds located adjacent to the Kennecott Mining Company mill at Kennicott (figs. 2 and 14). In four of six years in which outburst can be defined, the outburst occurred in May or June. They remain empty throughout the summer.

Numerous small supraglacial lakes are found on the Kennicott, Root, and Gates Glaciers. Individual lake volumes are relatively small compared with the volumes of the glacier-dammed lakes previously discussed, but the combined volume released when conduits are opened during lake outbursts may be significant.

**Figure 11.** Erie Lake draining, July 16, 1994. (Note wash line and lightly vegetated strandlines.)

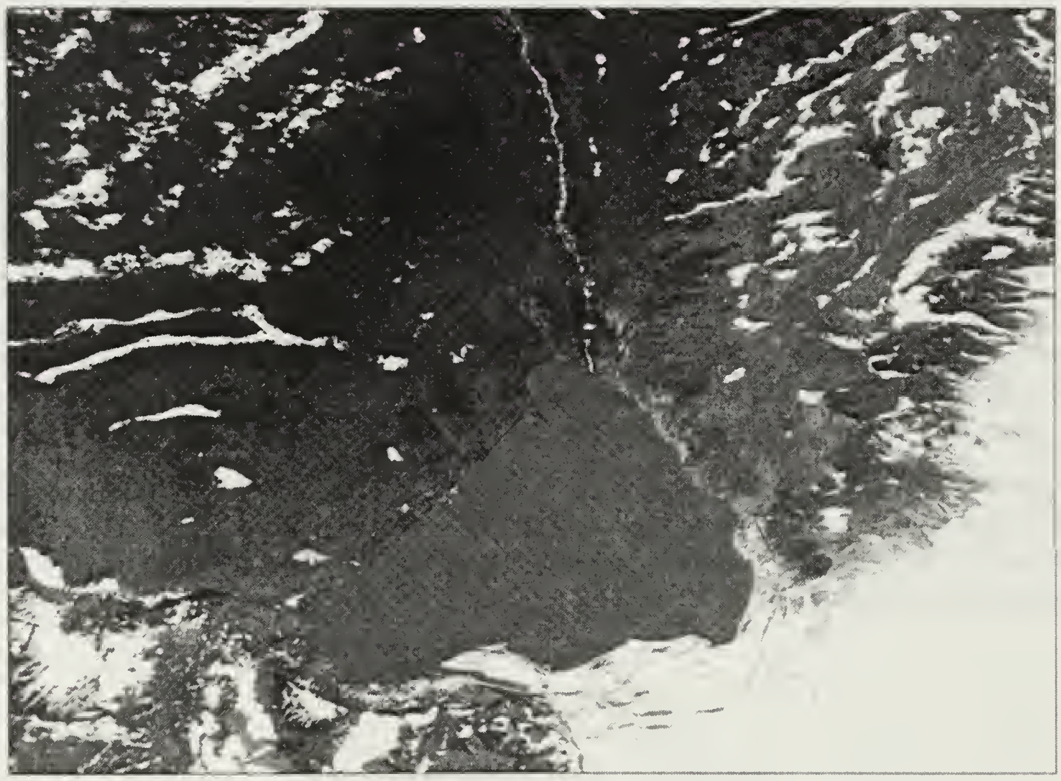


**Figure 12.** Donoho Lake on May 12, 1994, prior to its early summer outburst.

**Figure 13.** Jumbo Lake on May 12, 1994, prior to draining.

**Figure 14.** Bonanza Lakes near Kennecott mill site, May 12, 1994.

## Kennicott Glacier

### Internal Drainage

Englacial and subglacial drainage conduits generally follow the line of maximum hydraulic gradient (Embleton and King, 1975, p. 353). Hydraulic gradients were calculated using the 1957 maximum lake elevation for Hidden Creek Lake and the elevations of **lake/holes**, Jumbo Lake, and Donoho Lake. The largest hydraulic gradient (0.031 ft/ft) was from Hidden Creek Lake to east lake/hole 1 and west lake/hole 3 (shown on figures 16 and 19, respectively, later in this report), and the smallest (0.028 ft/ft) from Hidden Creek Lake to Donoho and Jumbo Lakes (fig. 2).

Outburst flood waters from Hidden Creek Lake enter Kennicott Glacier, refill Donoho and Jumbo Lakes, and emerge first along the eastern margin of Kennicott Glacier, not at the lake/holes of maximum hydraulic gradient. Historical records indicate that Hidden Creek Lake flood waters have consistently emerged from the glacier along the eastern margin above the East Fork Kennicott River (Bateman, 1922; McCarthy Weekly News, 1921-26; Janson, 1975; and Friend, 1988).

Bedrock and subglacial topography have an unknown influence on the internal drainage system. Small dacite knobs have recently become exposed through the thinning ice along the western flank of Kennicott Glacier. It is possible that these resistant bedrock knobs form topographic high points underneath Kennicott Glacier (fig. 15), south of Fourth of July Creek (fig. 2), and may divert englacial and subglacial water toward Donoho Lake and the eastern margin of the glacier. Crevasse patterns suggest that the glacier passes over an irregular subsurface in this region. Mapping of subglacial landforms was beyond the scope of this study. If the dacite forms discontinuous high points or is not present, future outburst flood water may emerge from the western side of Kennicott Glacier. Future flood hazard potential would change significantly if more of the outburst flood waters were to emerge from the western side of the glacier.

A series of **en echelon** fractures were developed in Kennicott Glacier adjacent to Root Glacier in 1994 and 1995 as flood waters flowed to Jumbo Lake. During the early part of the 1994 Hidden Creek Lake outburst, the hydraulic pressures were sufficient to fracture the ice. Numerous supraglacial ponds drained and water was observed to flow from these fractures. During outburst floods, supraglacial lakes and possible englacial and subglacial waters are tapped, compounding the flood magnitude in the Kennicott River.

### Terminus Advance and Retreat

The maximum advance of Kennicott Glacier is estimated to have occurred about 1860. This estimate is based on tree-ring data collected from stands of trees in the Kennicott basin and glacier margins (Barry Hecht, Balance Hydrologic, Inc., oral commun., 1996; Viereck, 1967). Kennicott Glacier and associated outwash areas have changed dramatically as the glacier has retreated from its 1860 maximum (figs. 16-19).

Changes in the glacier terminus were small between 1860 and 1909, as shown by the plan map generated during the survey for the Copper River and Northwestern Railway (fig. 20), which depicts the glacier margin near its maximum extent. Survey data from 1911, 1912, and 1920 suggest that glacier retreat began shortly after 1909. The western 1860 **trim line** was reported to be approximately 175 ft above the 1957 glacier position (Field, 1975). Photographs taken in the early 1900's show a significantly higher glacier ice surface elevation for areas near the Kennecott mill and glacier terminus. The terminus of Kennicott Glacier has retreated 2,000 ft since 1909 and the corresponding active stream channel/ice margin water elevation has dropped as much as 70 ft, as indicated from geomorphic profile surveys (figs. 21A-B). The average glacier retreat rate between 1909 and 1995 was approximately 20 ft annually (fig. 21A). Glacier retreat west of the West Fork Kennicott River has been less dramatic (figs. 16, 19, 21C-E).

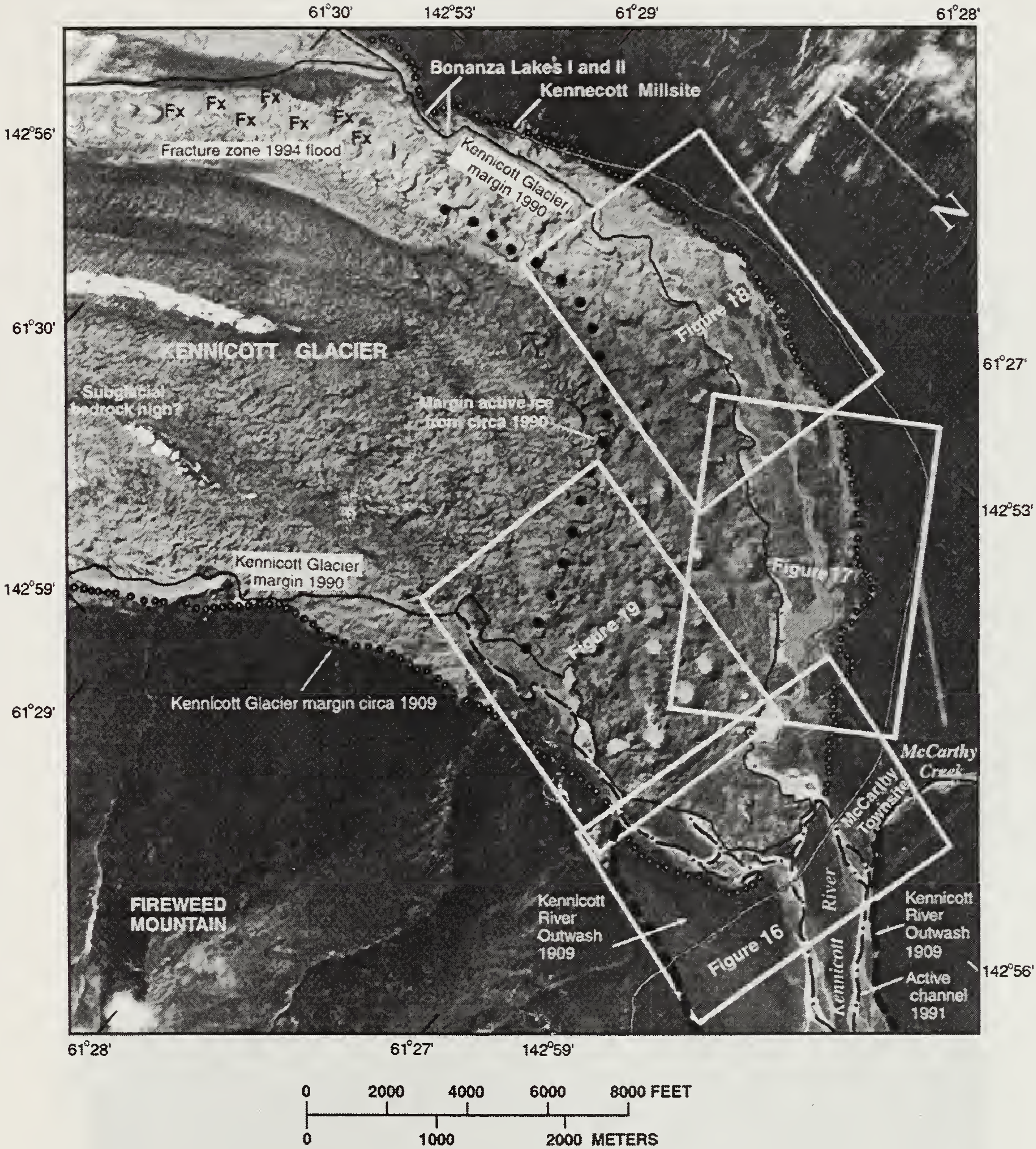



**Figure 15.** Kennicott Glacier and outwash history, 1860 to 1995, index map. (National Park Service Aerial Photograph)

## KENNICOTT GLACIER AND OUTWASH HISTORY, 1860 TO 1995

## EXPLANATION FOR FIGURES 16, 17, 18, AND 19

| | | |
|---|---|---|
| 1860 | X–X–X–X–X | Feature formed in association with 1860 advance |
| | | Leading edge of 1860 moraine |
| | X–––X–––X | Pre-1909: feature formed during 1860-1909 period |
| | | Pre-1909: channel formed during 1860-1909 period |
| 1909 | | Circa 1909 feature or channel |
| 1925 | ······ 1925 ······ | Circa 1925 channel |
| 1937 | | Circa 1937 lake or channel |
| 1957 | | Circa 1957 lake or channel |
| 1966 | X X X X X X | Circa 1966 channel |
| 1970 | □ □ □ □ □ □ | Circa 1970 channel or lake |
| 1978 | —— 1978 —— | Circa 1978 channel |
| 1983 | ■ ■ ■ ■ ■ ■ | Circa 1983 channel or lake |
| 1985 | ▲ ▲ ▲ ▲ ▲ | Circa 1985 channel or lake |
| 1988 | —— 1988 —— | Circa 1988 channel or lake |
| 1990 | Photo base | Circa 1990 feature (aerial photograph, August 22, 1990, scale 1:10,500) |
| 1994 | —— 1994 —— | Circa 1994 feature |
| 1995 | —— 1995 —— | Circa 1995 feature |

| | |
|---|---|
| | Margin geomorphic feature |
| | Margin active ice front, pre-1948 |
| | Margin active ice front, 1990 |
| 1970-83 | Minimum known time period that channel/lake was active |
| 1985 | Point where water exits glacier and corresponding year |
| ★ | Geomorphic profile monument |
| GP2 | Geomorphic profile and number (see fig. 21) |
| | Trees buried by outwash deposits 860 years before present: Carbon-14 dating (Gordon Jacoby, Tree Ring Laboratory, Columbia University, written commun., 1995.) |
| Fx | Fracture in ice |
| L | Lake or pond |
| FP | Flood plain |
| CH | Channel |
| OW | Outwash |
| FLD | Flood |
| B | Waterboil/fountain |
| PH | Historic "pothole" feature |
| ELH /WLH | East or West lake/hole where water accumulates or exits glacier |

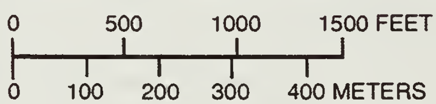



**Figure 16.** Kennicott Glacier and outwash history, southside.

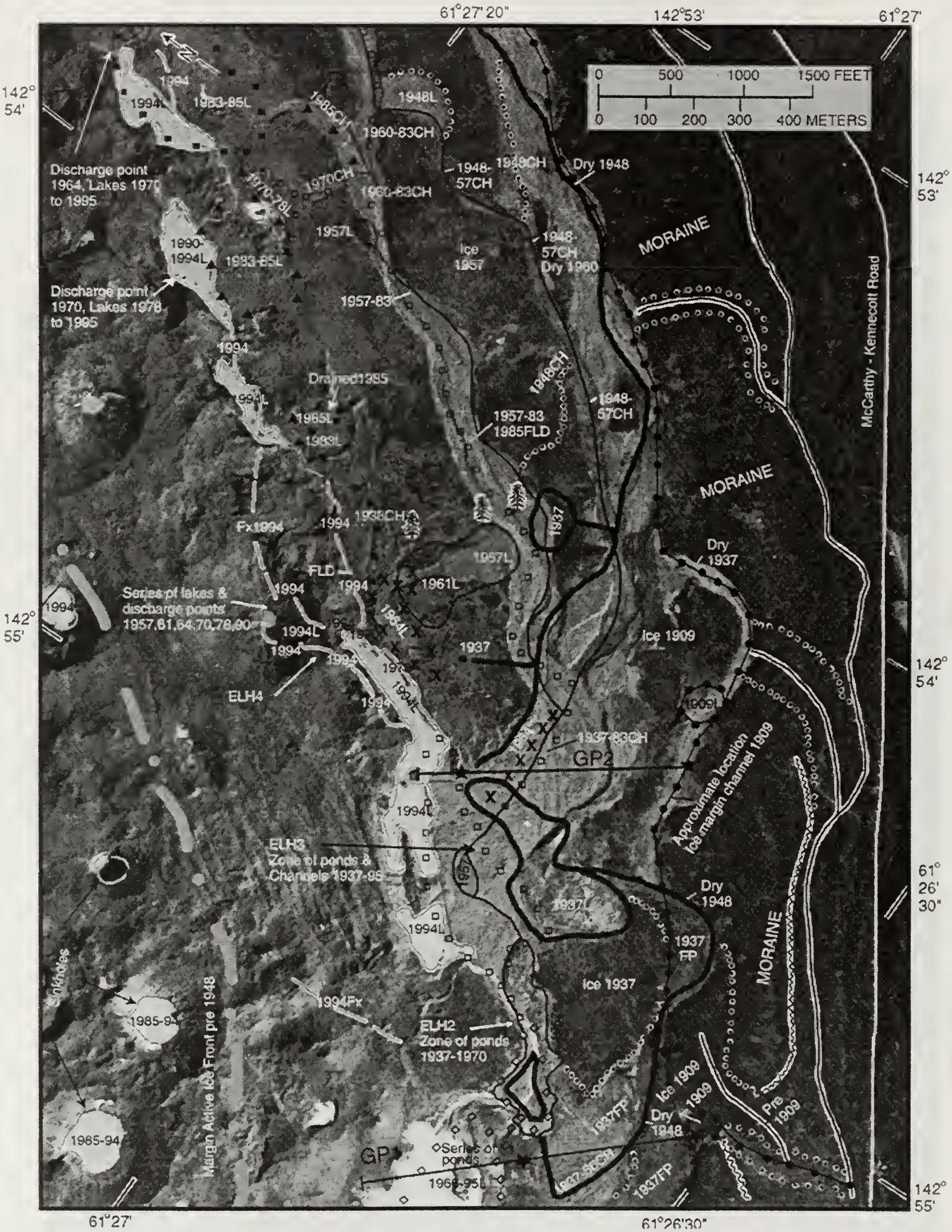



Figure 17. Kennicott Glacier and outwash history, lower east side.

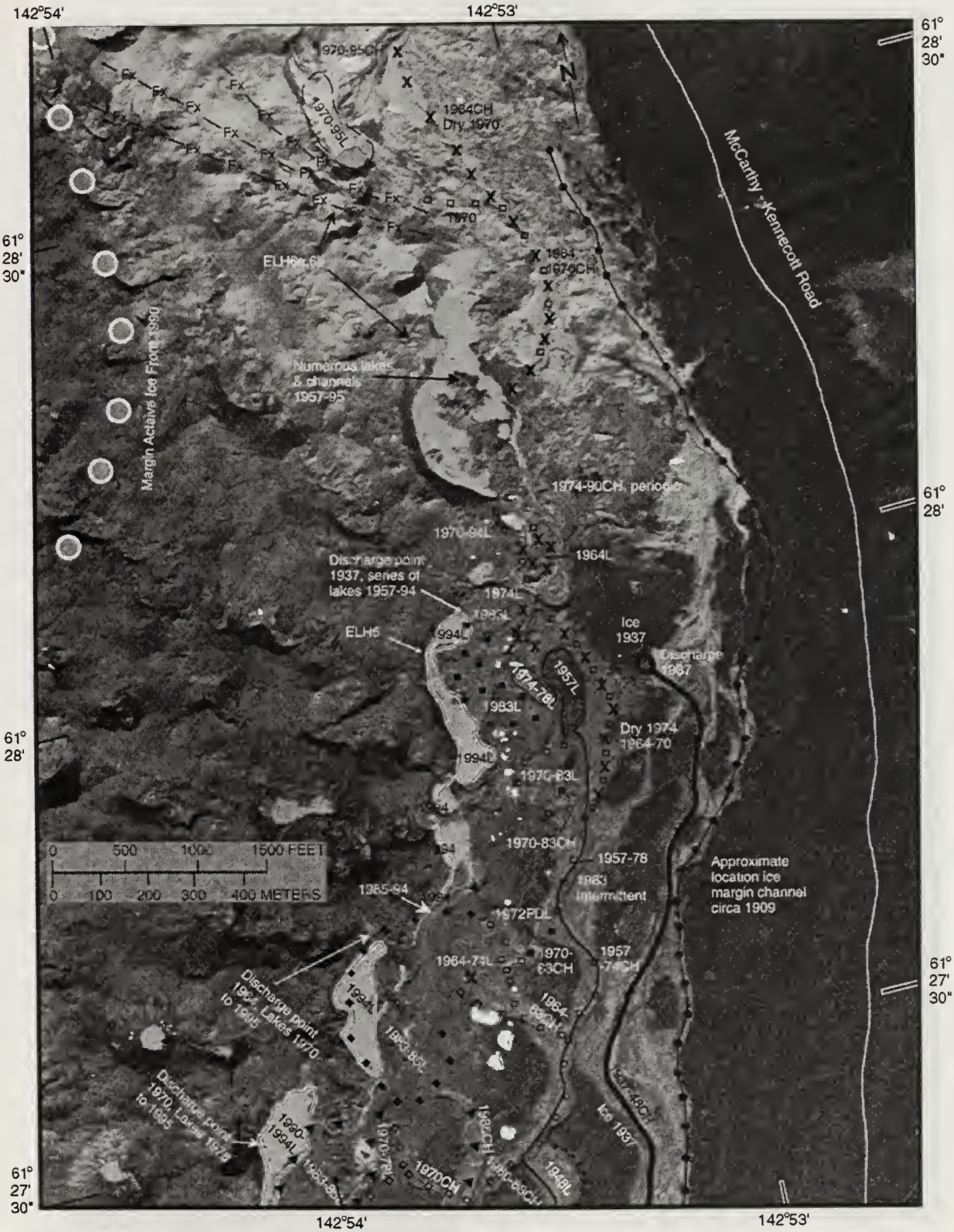



Figure 18. Kennicott Glacier and outwash history, upper east side.

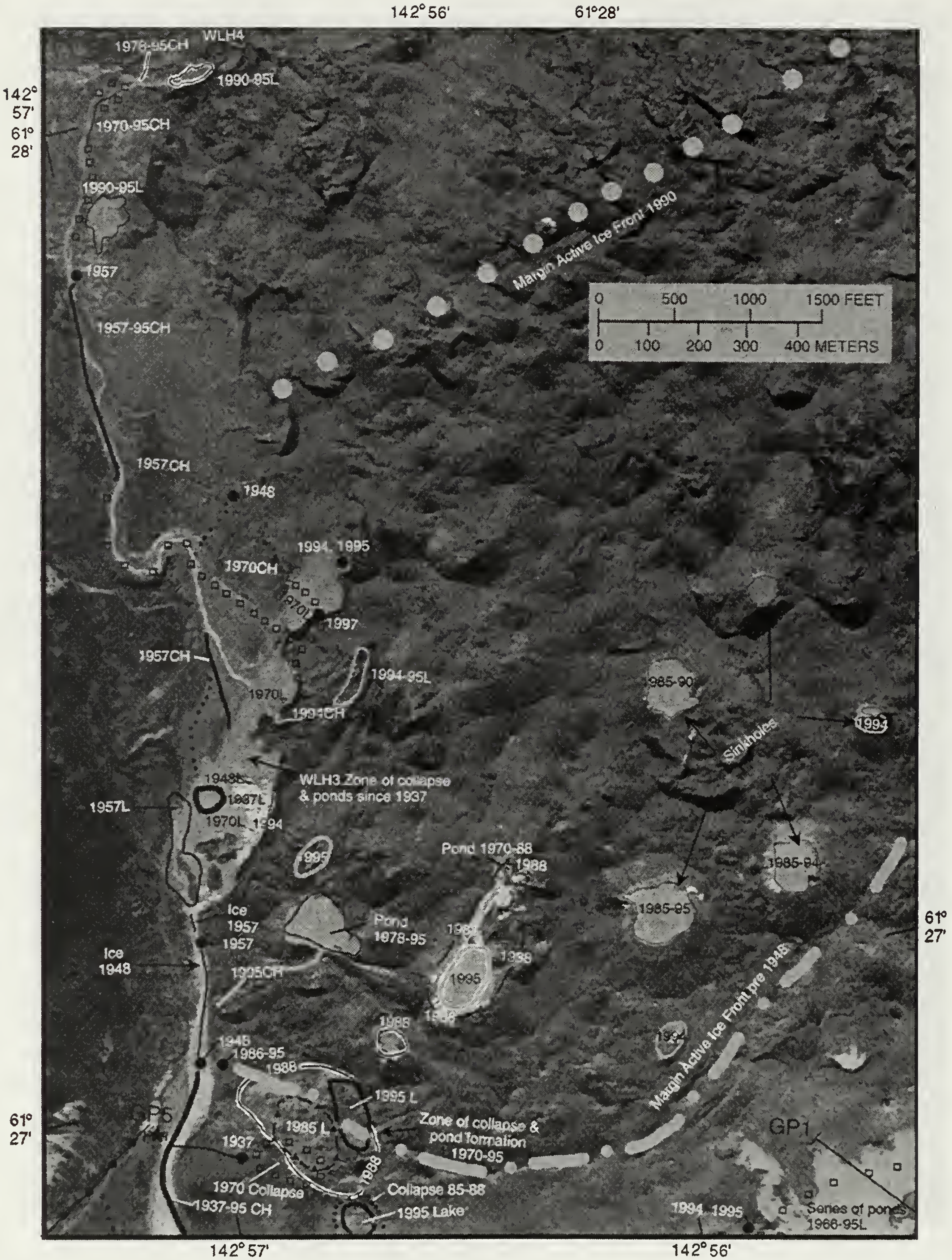
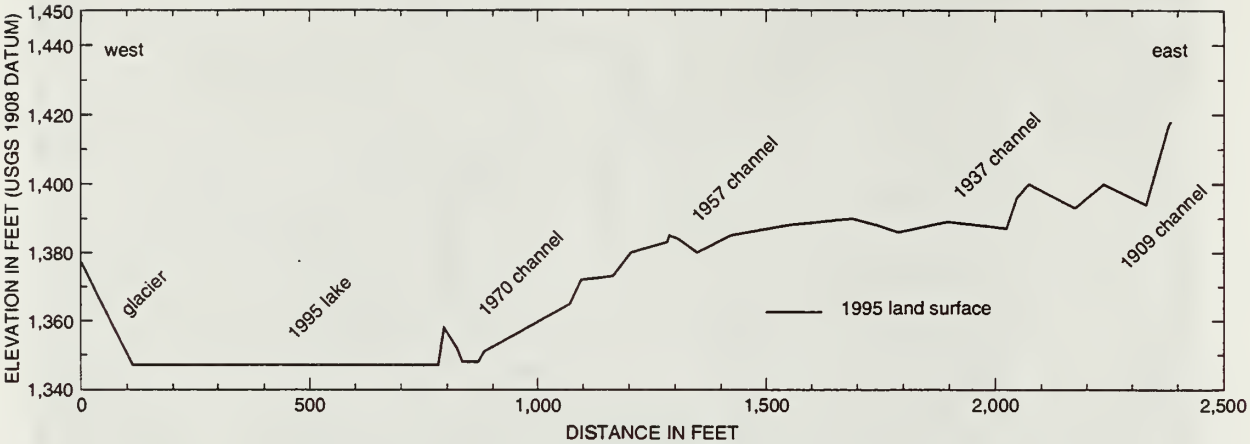
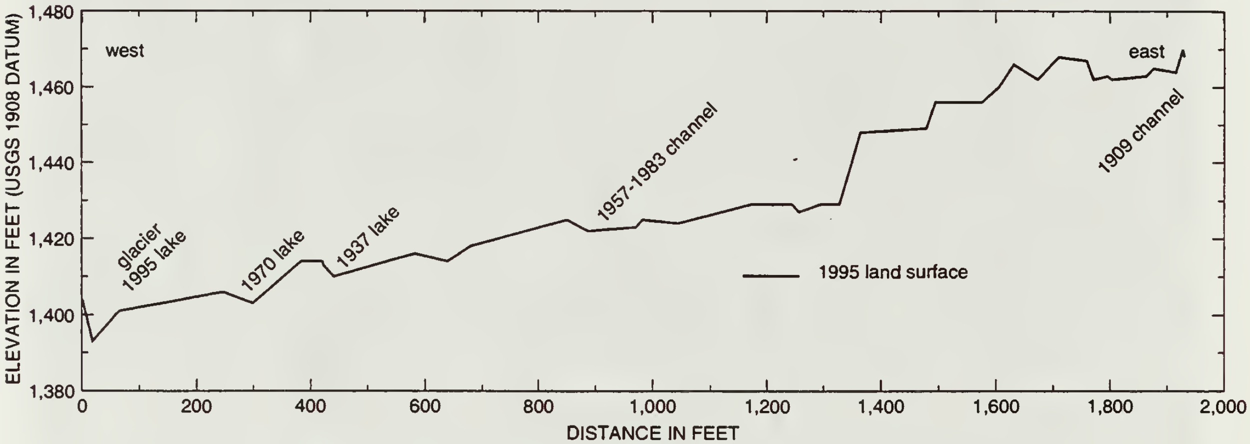



**Figure 19.** Kennicott Glacier and outwash history, west side.

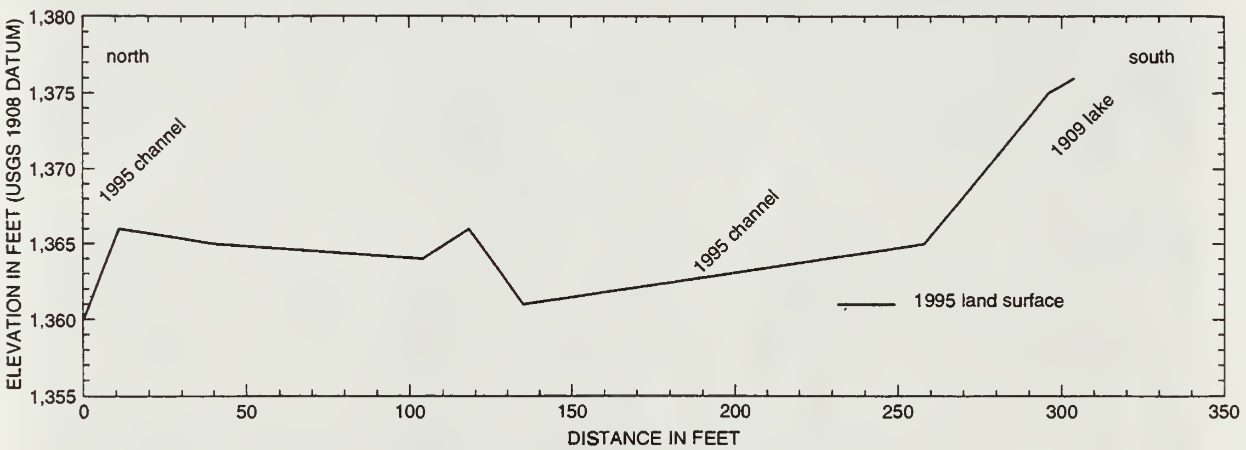

Figure 20. Copper River and Northwestern Railway 1909 survey plan view map.




A. Geomorphic profile 1, lower east side (see figures 16 and 17 for profile location).

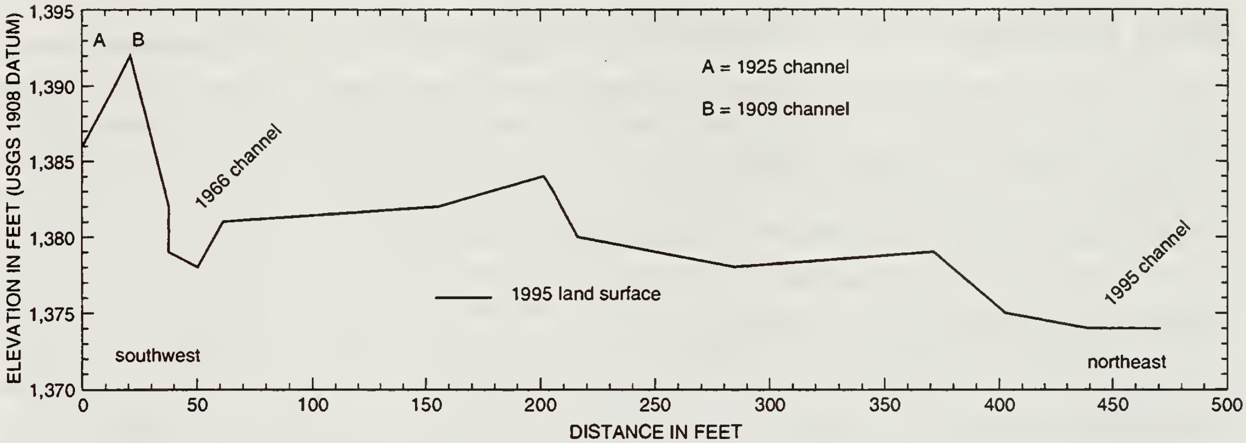



B. Geomorphic profile 2, upper east side (see figure 17 for profile location).

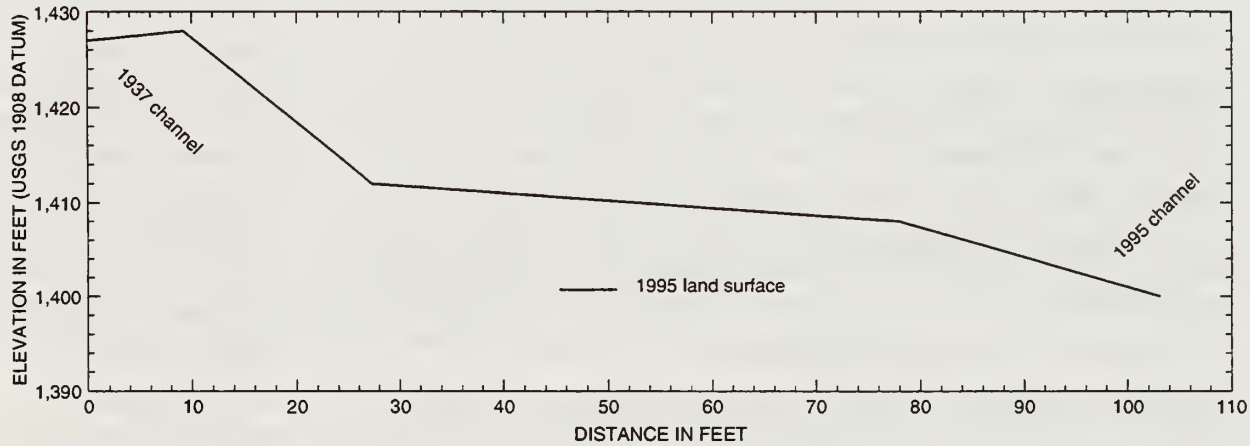



C. Geomorphic profile 3, south side (see figure 16 for profile location).

**Figure 21.** Geomorphic profiles of Kennicott Glacier outwash.




D. Geomorphic profile 4, lower west side (see figure 16 for profile location).




E. Geomorphic profile 5, upper west side (see figure 16 and 19 for profile location).

**Figure 21.** Continued.

### Outwash Area Evolution

To predict future changes, the stream channel and lake/hole morphology from 1860 to 1995 for Kennicott Glacier and its outwash area has been reconstructed using historical photographs and documents (table 3; figs. 15-19). Ice-margin lakes, active stream channels, discharge points, **sinkholes**, and glacial and geomorphic features are plotted for the following years: about 1860, pre-1909, about 1909, 1937, 1957, 1970, 1990, 1994, and 1995. In addition, selected information for 1925, 1966, 1978 and the 1980's is plotted.

Physical conditions in Kennicott Glacier and its outwash area evolve as the glacier thins and retreats. Recognizing the stages in this evolutionary sequence provides a useful tool for predicting future drainage pattern changes and assessing potential flood hazards. A recurring evolution pattern appears, which is most obvious along the southeastern margin where the glacier's retreat is most extensive. This study identified four general stages of outwash area evolution: ***karst***, *pond*, *active channel,* and *abandoned channel*. These constitute a continuum of conditions. In many areas, the characteristics overlap and merge, and not all conditions may be present at any given

**Table 3**. Documentation for the reconstruction of the Kennicott Glacier and its outwash area

| Source | Date |
|---|---|
| USGS map, Bulletin 374 (Moffit and Maddren, 1909) | 1907 |
| Copper River and Northwestern Railway survey maps | 1909 |
| United States Land Office (published 1920) | 1912 |
| Oblique aerial photography by Bradford Washburn | 1937-38 |
| Trimetrogon aerial photography | June 18, 1948 |
| Aerial photography, USGS, scale 1:48,000 | July 27, 1957 |
| Oblique aerial photograph, USGS | August 8, 1960 |
| Oblique aerial photograph, USGS | July, 1961 |
| Oblique aerial photographs, USGS | August 24, 1964 |
| Oblique aerial photograph, USGS | July 20, 1966 |
| Oblique aerial photograph, USGS | August 27, 1969 |
| Aerial photograph. Aeromap, Inc., scale 1:20,000 | August 26, 1970 |
| Aerial photograph. National Aeronautic and Space Administration, scale 1:60,000 | July 21, 1972 |
| Aerial photography, USGS, scale 1:12,000 | September 1, 1974 |
| Aerial photograph. Aeromap, Inc., scale 1:2,000 | June 11, 1976 |
| Aerial photograph. National Aeronautic and Space Administration, scale 1:60,000 | August 1978 |
| Aerial photograph. Aeromap, Inc., scale 1:12,000 | August 19, 1983 |
| Oblique aerial photograph, USGS | August 24, 1984 |
| Aerial photograph, National Park Service, scale variable | September 12, 1985 |
| Aerial photograph, National Park Service, scale variable | August 10, 1988 |
| Aerial photograph, National Park Service, scale variable | August 22, 1990 |
| Aerial photograph, University of Alaska Fairbanks, Office of Land | June 14, 1994 |
| Oblique photographs, National Park Service | 1994 |
| Oblique photographs, National Park Service | 1995 |

time. These four stages consist of a set of physical conditions that form and respond to ablation, glacial retreat, and complex supraglacial, englacial, and subglacial drainage controls. Small annual changes are common and catastrophic changes are known to occur, especially during outburst floods. A similar pattern of evolution is also observed in the lower reaches of the Kuskulana Glacier northwest of McCarthy (fig. 1) and Nadina Glacier (terminus, about 70 mi. northwest of McCarthy).

The *karst* stage occurs below the active parts of the glacier within the moraine-covered stagnant ice areas (figs. 16-19), in which tension fractures indicative of ice movement are absent. Characteristically, the karst stage contains small and large sinkholes, which are quasi-stationary. Initially, these features are circular in plan view, and cone shaped, but as their perimeters melt and collapse, they become elongated, which suggests linear englacial or subglacial channel controlling mechanisms. Small ponds occur within the karst areas, some of which evolve from sinkholes and others from collapse zones. During glacier-dammed lake outbursts, these sinkholes and ponds fill, which suggests a connection with the internal drainage system of Kennicott Glacier. Englacial and subglacial conduits are active in the karst stage. As melting progresses, caverns and passages form and expand. They persist from year to year. Discharge from west lake/hole 3 (WLH3, fig. 19)—which lies within the karst area—increases during outbursts, suggesting that it is connected to the glacier's internal drainage system, whereas west lake/hole 4 (WLH4, fig. 19), situated in the active glacier, has a constant discharge during outburst floods. The karst area acts like a large sponge during outburst floods. Large volumes of flood water are temporarily retained in the karst area, especially during the initial stages of an outburst when caverns and ponds are filling with water.

The *pond* stage occurs as Kennicott Glacier thins and retreats. Remnant karst sinkhole features persist and subglacial channels carry water between ice margin ponds. The ponds form embayments into the stagnant glacier ice along the ice-outwash margin and in the stagnant glacier ice adjacent to the margin. Most ponds are elongated (figs. 16-19) and change size and location over time. They eventually merge forming elongated ponds between the outwash gravel and glacier ice. Some of the lakes show dramatic stage changes during outbursts, suggesting that they are connected by englacial and subglacial channels. Ice-margin lakes, such as those observed near east lake/hole 4 (ELH4, fig. 17), have persisted as geomorphic features (1937, 1957, 1964, 1970, and 1990) and are connected to the internal drainage system of the glacier.

A transition to the *active channel* stage occurs as the ice-margin lakes connect, undercutting the ice margin or downcutting through outwash deposits. Between 1909 and 1995, the active channel position has migrated toward the center of the valley (figs. 16-18), and streambed elevation has declined (fig. 21). Active channels carry water for periods ranging from a few years to more than 25 years (fig. 16). Some active channels are eventually separated from the glacier margin by islands of moraine-covered ice, as noted for the 1909 and 1937 ice locations (figs. 16 and 18). Eventually, the elevation of the active channel becomes higher than that of the glacier margin ponds. Downcutting and migration of active channels may occur rapidly in unconsolidated outwash sediments. For example, a channel downcut approximately 20 ft into unconsolidated outwash sediments in the east lake/hole 4 area during the 1994 Hidden Creek Lake outburst flood (fig. 22).

The final stage of outwash area evolution is the *abandoned channel*. Catastrophic and small annual changes in the drainage system cause active channels to be abandoned. Abandoned channels are initially connected to bodies of water along the glacier margin. Englacial and subglacial channels become the new active conduits, lowering the pre-existing water-surface elevation which causes the older active channel to be bypassed. Initially, some of these abandoned channels carry flood water, but are eventually abandoned completely. The 1909 and 1937 channels along the eastern margin are examples of abandoned channels (figs. 16 and 18). Eventually abandoned channels are perched at elevations outside of any current flood hazard zone (fig. 21).

**Figure 22.** Channel downcutting near east lake/hole 4 resulting from the 1994 Hidden Creek Lake outburst flood.

## Kennicott River

### Source

The source of the Kennicott River is the Kennicott Glacier. The flow regime of the river is modified by increasing and decreasing snowmelt and icemelt, rainfall, lake outbursts, and groundwater inflow.

Outburst water from Hidden Creek Lake travels along undelineated englacial and subglacial conduits and issues from numerous locations along the margin of Kennicott Glacier. During outbursts, water boils out from beneath the glacier at discrete points. The "**pothole**," described and photographed in the early 1900's, is the most well-known example (fig. 20). It was located adjacent to the Copper River and Northwestern Railway bridge and was most active during the Hidden Creek Lake outbursts. The pothole and west lake/hole 2 were active in 1909; they have since remained active, but have migrated 2,000 ft up-glacier, and are likely to continue migrating up-glacier. Migration up-glacier of east lake/hole 4, and west lake/hole 2 could result in the capture of other active channels and increase the hydraulic efficiency of the glacier's internal drainage system. Shreve (1972) and Hooke (1989) conclude that increased hydraulic efficiency could result in sharper and higher discharge peaks.

Seven discharge sites were active during the 1994 and 1995 outbursts. Large volumes of water issued from the glacier at east lake/hole 6 (ELH6a, 6b, fig. 18) and west lake/hole 2 (WLH2, fig. 16) during the 1994 and 1995 outbursts. Flood water in 1994 and 1995 traveled through and adjacent to the karst zone along the eastern side and adjacent to the western margin of the Kennicott Glacier from west lake/hole 3 (WLH3, fig. 19).

#### Stage and Streamflow

Gages installed on the West and East Forks Kennicott River used a common datum established by GPS surveying techniques. On the West Fork Kennicott River, seasonal stage and streamflow data were obtained from 1992 to 1995 using the methods described by Rantz and others (1982). River stage was recorded at 30-minute intervals. Crest-stage gages were used to verify recorded maximum stage. On the East Fork Kennicott River, staff gages and a crest-stage gage were read daily in 1991 and periodically from 1992 through 1995. Frequency of staff-gage readings increased during floods.

Stage-discharge relations for both forks were developed by using current-meter discharge measurements during periods of low flow (Buchanan and Somers, 1969). For periods of medium to high flows, the relations were developed by using **slope-area** (Dalrymple and Benson, 1967; Fulford, 1994) and **step-backwater** (Davidian, 1984; Shearman and others, 1986; Shearman, 1990) indirect methods. It was not possible to measure flood water discharge directly using current meter methods because of safety concerns.

The Alaska Department of Transportation and Public Facilities (ADOT&PF) provided two topographic maps (1-foot contour interval) of the transportation corridor (which occupies the old Copper River and Northwestern Railway bed) and tram areas on the East and West Forks Kennicott River. The first map was based on a May 1994 survey made before the Hidden Creek Lake outburst flood, and the second was based on an October 1994 survey made after the outburst flood. Both ADOT&PF surveys used an arbitrary vertical datum. Channel cross-section information used for indirect discharge measurements on the West Fork Kennicott River was derived from the ADOT&PF maps and adjusted to the USGS 1908 datum. A summary of datum adjustments are listed in appendix 2.

Stage hydrographs (1992-95 water years) for the West Fork Kennicott River are shown in figure 23 (Schellekens and others, 1996). Maximum stage and corresponding discharge for selected events are presented in table 4. Combined East and West Fork Kennicott River discharge volumes from Hidden Creek Lake outburst floods averaged 2.1 billion cubic feet (appendix 5).

Annual maximum stages for the 1992-95 water years occurred during the Hidden Creek Lake outburst floods (fig. 23, table 4). The highest stage observed during this study was 1,353.16 ft at the West Fork Kennicott River gage and 1,363.82 ft at the East Fork Kennicott River gage. Rises in stage from Erie Lake outbursts are also evident, as are some rainfall events. Sharp peaks attributed to englacial or subglacial releases (Johnson, 1990) were evident during the summers of 1992 and 1993, but not during 1994 or 1995. Stage rises from other glacier-dammed lake failures, including Donoho, Gates, Bonanza, and Jumbo Lakes, are not evident. A gradual, but noticeable rise in stage on the West Fork Kennicott River is evident during the days preceding the Hidden Creek Lake outburst floods (fig. 23). The rise preceding the 1994 flood coincides well with the observed gradual drop in lake level at Hidden Creek Lake. Friend (1988) noted this same phenomenon during the 1986 outburst flood.

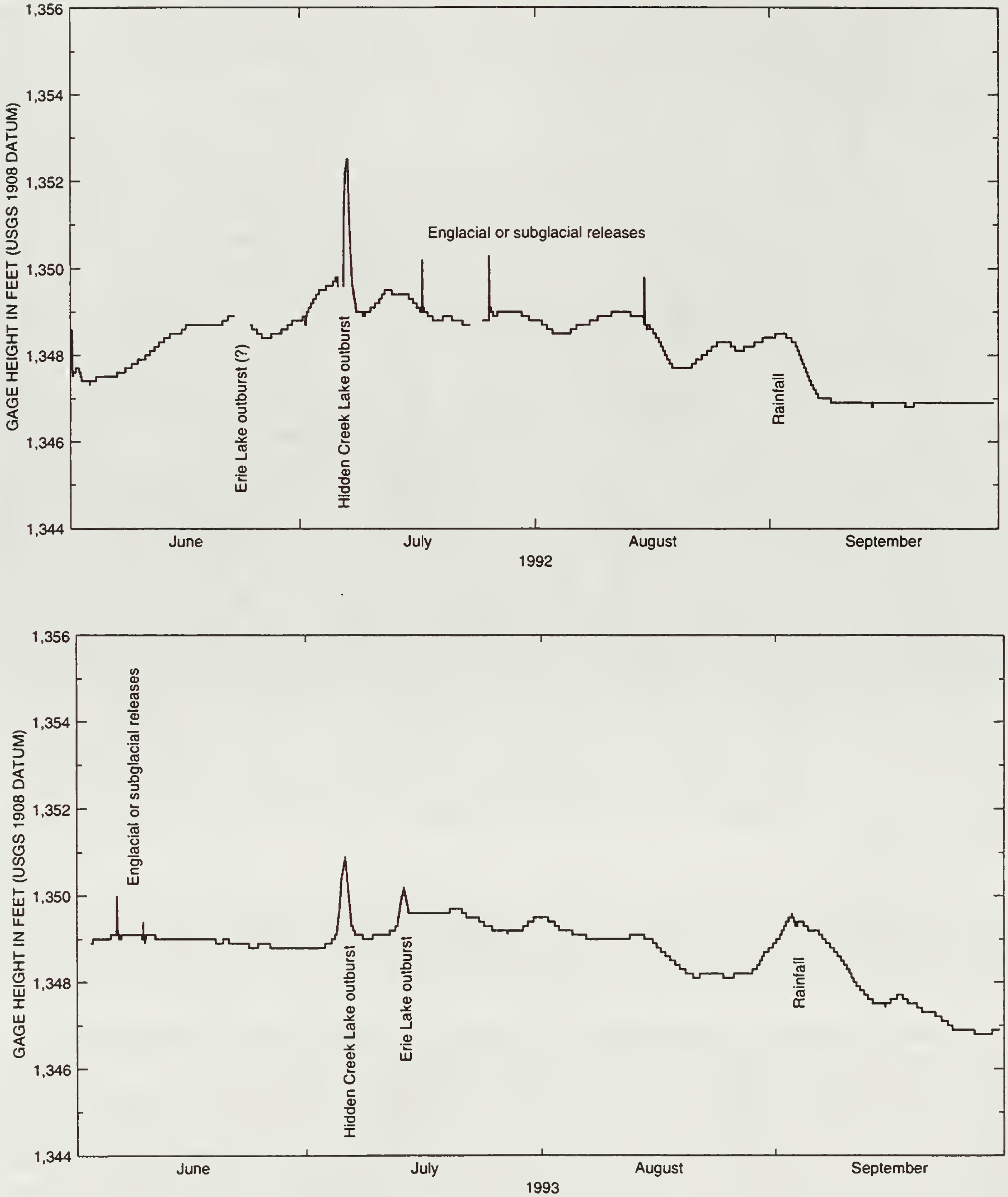
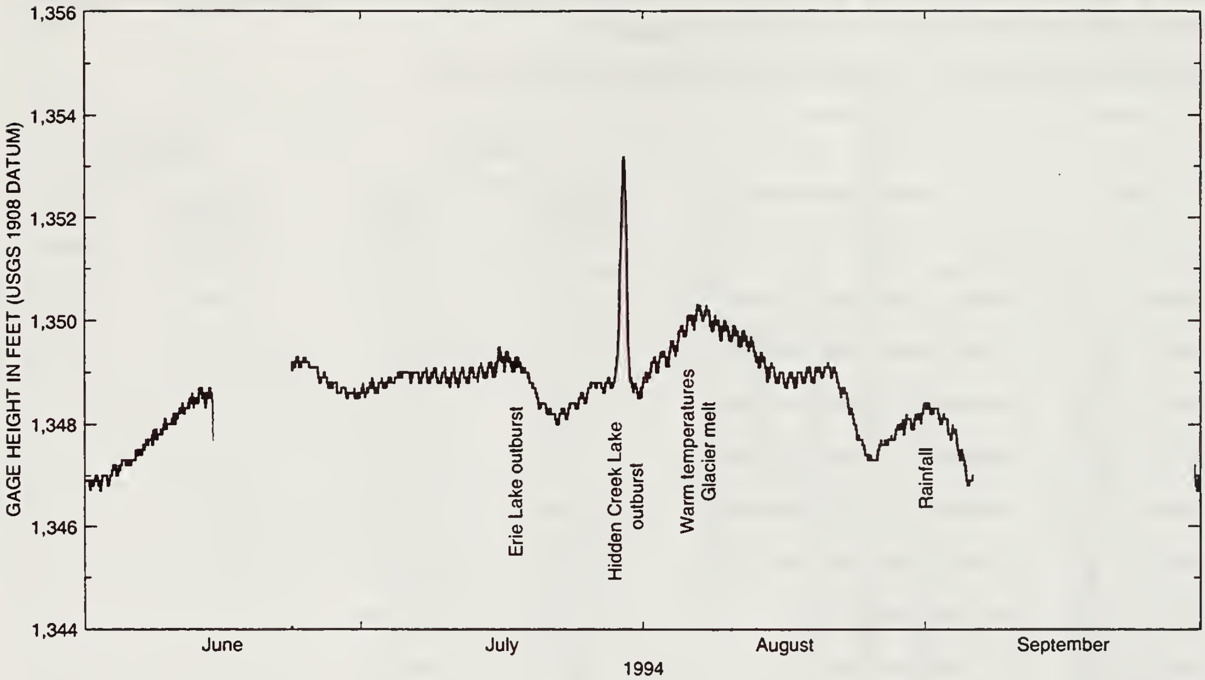



**Figure 23.** West Fork Kennicott River stage and explanation for peaks, June through September, 1992 to 1995.



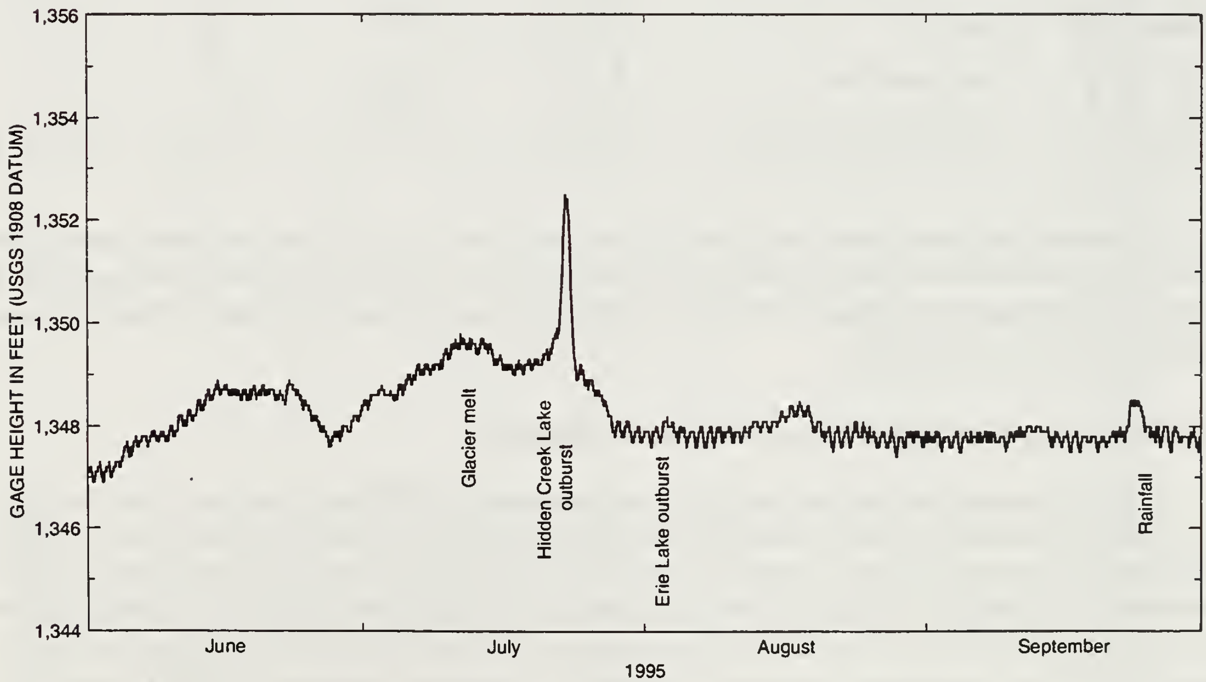




**Figure 23.** Continued.

**Table 4.** Maximum discharge and stage for selected hydrologic events on the East and West Forks Kennicott River, 1991 to 1995 water-years

[$ft^3/s$, cubic feet per second; ---, unknown; data from Schellekens and others, 1996]

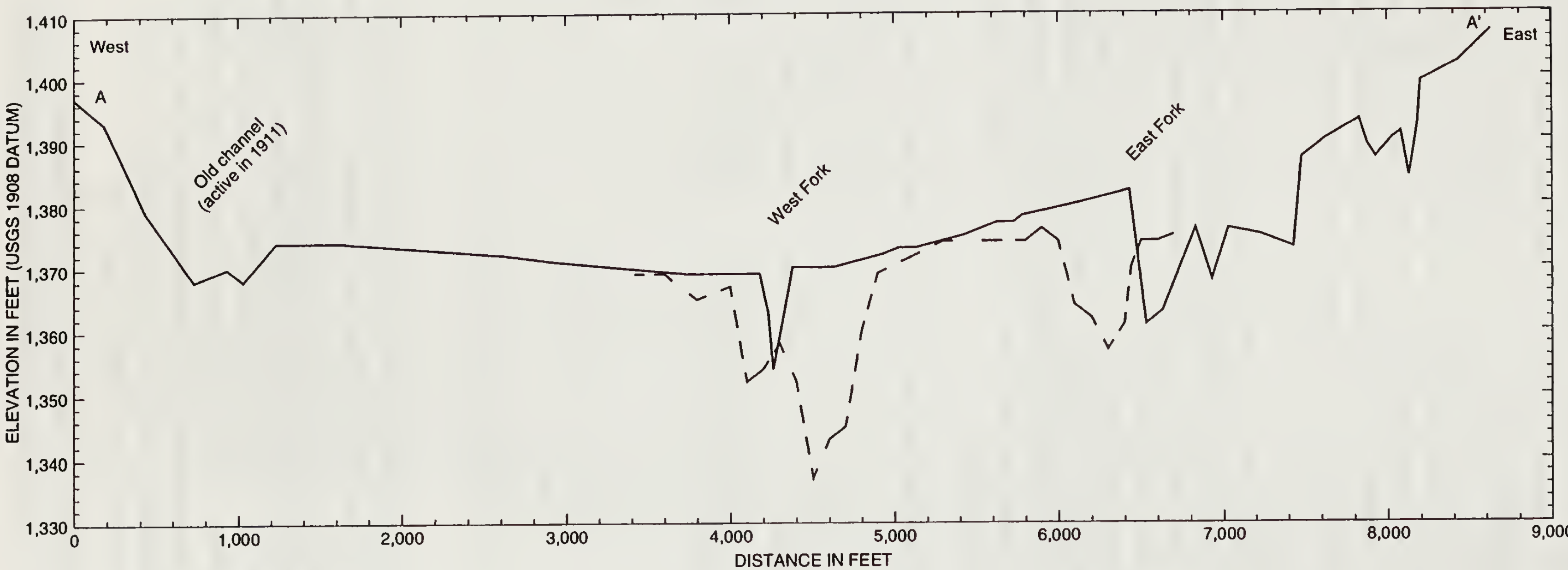
| Date | Hydrologic event | West Fork | | East Fork | |
|---|---|---|---|---|---|
| | | Discharge ($ft^3/s$) | Stage (feet) | Discharge ($ft^3/s$) | Stage (feet) |
| August 4, 1991 | Hidden Creek Lake outburst | 20,000 | 1,352.22 | 4,500 | 1,363.82 |
| July 7, 1992 | Hidden Creek Lake outburst | 23,200 | 1,352.51 | 3,820 | 1,363.16 |
| July 17, 1992 | Englacial or subglacial release | 10,900 | 1,350.21 | --- | --- |
| July 25, 1992 | Englacial or subglacial release | 11,100 | 1,350.27 | --- | --- |
| June 6, 1993 | Englacial or subglacial release | 10,200 | 1,349.98 | --- | --- |
| July 6, 1993 | Hidden Creek Lake outburst | 13,500 | 1,350.87 | --- | --- |
| July 13, 1993 | Erie Lake outburst | 10,800 | 1,350.18 | --- | --- |
| July 16, 1994 | Erie Lake outburst | 8,810 | 1,349.52 | --- | --- |
| July 29, 1994 | Hidden Creek Lake outburst | 28,000 | 1,353.16 | 3,900 | 1,363.24 |
| August 7, 1994 | Rainfall | 11,200 | 1,350.31 | --- | --- |
| July 11, 1995 | Warm; glacier melt | 9,550 | 1,349.76 | --- | --- |
| July 23, 1995 | Hidden Creek Lake outburst | 23,400 | 1,352.54 | 2,190 | 1,361.42 |

Historical maximum flood stages at the East and West Forks Kennicott River have been higher than those observed during this study. It is not known if historical flood discharges were larger or smaller than those observed during this study, because hydraulic properties have not been determined for historical floods.

### River Channel Erosion, Aggradation, and Channel Migration

The lower terraces and active flood plain are composed of **alluvium** extending from the Kennicott Glacier terminus to the confluence with the Nizina River (MacKevett and Smith, 1972). These deposits consist of poorly sorted silt, sand, gravel, cobble, and boulder-sized material. **Glacial erratics** as large as 12 ft in diameter are common in the alluvium. An alluvial terrace lies on the western side of the West Fork active channel, as well as between the West and East Forks Kennicott River. These deposits are somewhat protected by a terminal moraine (fig. 16). Channel erosion, aggradation, and migration occur in response to thinning and retreat of Kennicott Glacier (figs. 16-19).

A profile taken along the Copper River and Northwestern Railway bed (fig. 24) shows the significant channel changes that have occurred between 1911, when the railroad survey was made, and 1994 when the ADOT&PF surveys were made.




VERTICAL EXAGGERATION X 40

EXPLANATION

——— 1911 survey, adjusted to USGS datum

\- - 1994 ADOT&PF survey, adjusted to USGS 1908 datum

A - A' Line of profile shown in figure 16

**Figure 24.** Channel location and size in 1911 and in 1994 for the East and West Forks Kennicott River (profiles follow old railroad bed of the Copper River and Northwestern Railway).

An abandoned channel in the old alluvium terrace approximately 0.5 mi west of the West Fork Kennicott River (fig. 24) was active in 1911 (Danliquist, 1921) and remained active through at least 1937 (fig. 16). It is now perched approximately 40 ft above the active channel (fig. 21A). The West Fork Kennicott River currently occupies a much larger channel than the 1911 channel (fig. 24). The current channel has downcut nearly 20 ft and has migrated to the east. The East Fork Kennicott River currently occupies a much smaller channel than the 1911 channel and has migrated to the west. The East Fork Kennicott River main channel is well armored with boulders and has a smaller bed slope (0.004 ft/ft), making it more stable than the west channel, which consists of finer material and a steeper bed slope (0.012 ft/ft).

A capture channel between the East and West Forks Kennicott River formed during 1988 immediately upstream from the terminal moraine as the old ice under the glacier terminus melted, exposing the west-sloping subglacial terrain. This capture channel has captured progressively larger percentages of flow from the East Fork and added it to the West Fork each year during this study (table 5). The West Fork Kennicott River carried 68 percent of the total peak discharge in 1986 (prior to the formation of the capture channel) and 91 percent in 1995. During the summer of 1995, the East Fork Kennicott River was dry except during the Hidden Creek Lake outburst flood. This trend is likely to continue as the capture channel becomes more incised, eventually concentrating the entire Kennicott River flow into the West Fork.

**Table 5.** Discharge for selected outburst floods and percentage of total discharge for the East and West Forks Kennicott River

| Date | Outburst flood maximum discharge (cubic feet per second) | | | Percentage of total discharge | |
|---|---|---|---|---|---|
| | West Fork | East Fork | Combined | West Fork | East Fork |
| August 6, 1986[1] | 12,100 | 5,600 | 17,700 | 68 | 32 |
| August 4, 1991 | 20,000 | 4,500 | 24,500 | 82 | 18 |
| July 7, 1992 | 23,200 | 3,820 | 27,000 | 86 | 14 |
| July 29, 1994 | 28,000 | 3,900 | 31,900 | 88 | 12 |
| July 23, 1995 | 23,400 | 2,190 | 25,600 | 91 | 9 |

[1]Data from Friend (1988)

An abrupt channel change was observed on the West Fork Kennicott River during the 1994 Hidden Creek Lake outburst flood (Edward LaChapelle, Randy Elliot, oral commun., 1994). Flow concentrated in the center of the channel upstream from the tram suddenly shifted toward the right bank. This sudden channel change was also noted on the stage record of the USGS gage. Plots of four cross sections (fig. 25) were made using the pre- and post Hidden Creek Lake outburst flood survey data from the ADOT&PF. The cross sections show that upstream from the tram, the **thalweg** moved toward the right bank and scoured approximately 6 ft; downstream from the tram, it moved more toward the center and filled approximately 5 ft (fig. 25). The right bank was severely scoured at all four cross sections. Cross-section locations are shown on figure 26.

The presence of **aufeis** in rivers can increase channel and bank erosion (Slaughter, 1990, p. 449). Aufeis formation is greatest during years when snowpack is low early in the winter (Johnson

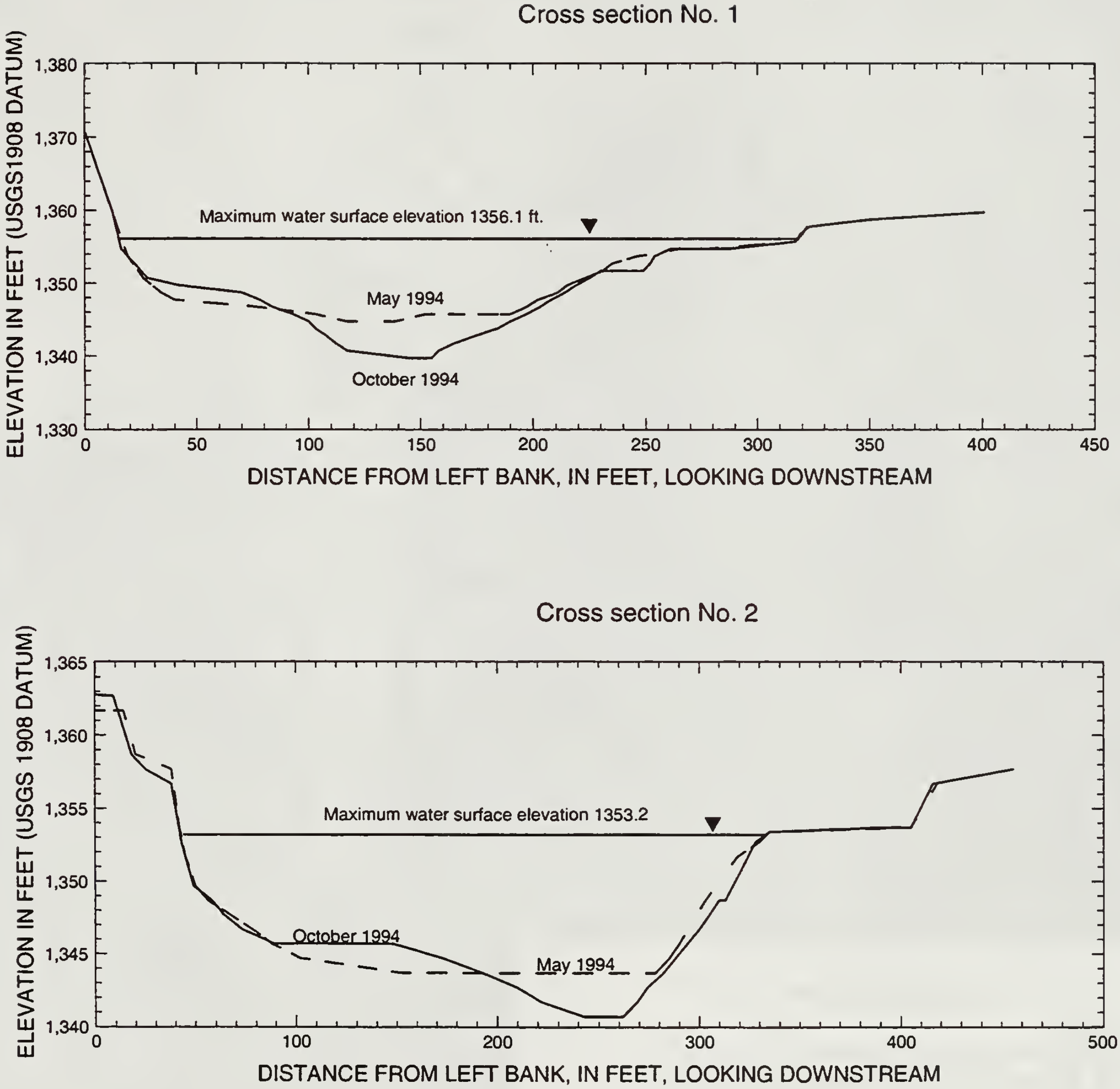
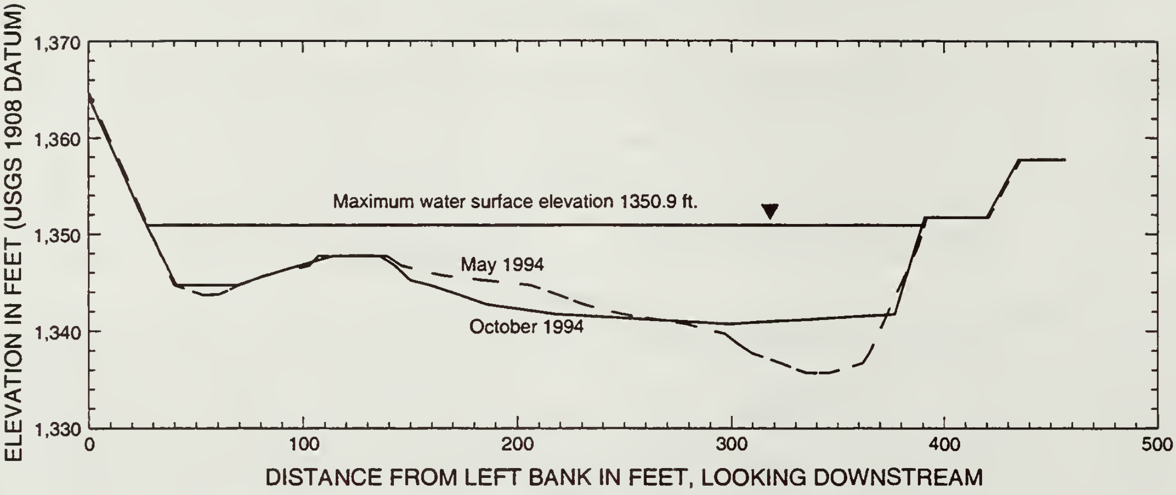



**Figure 25.** Pre- and post flood channel cross sections on the West Fork Kennicott River, Hidden Creek Lake outburst flood of July 29, 1994 (see figure 26 for cross-section locations).

Cross section No. 3




Cross section No. 4

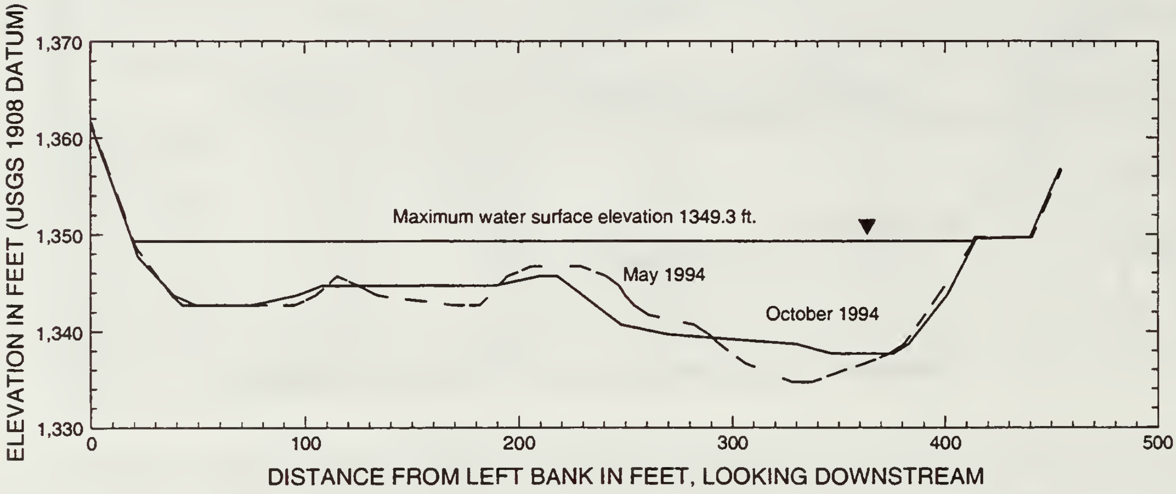



**Figure 25.** Continued.

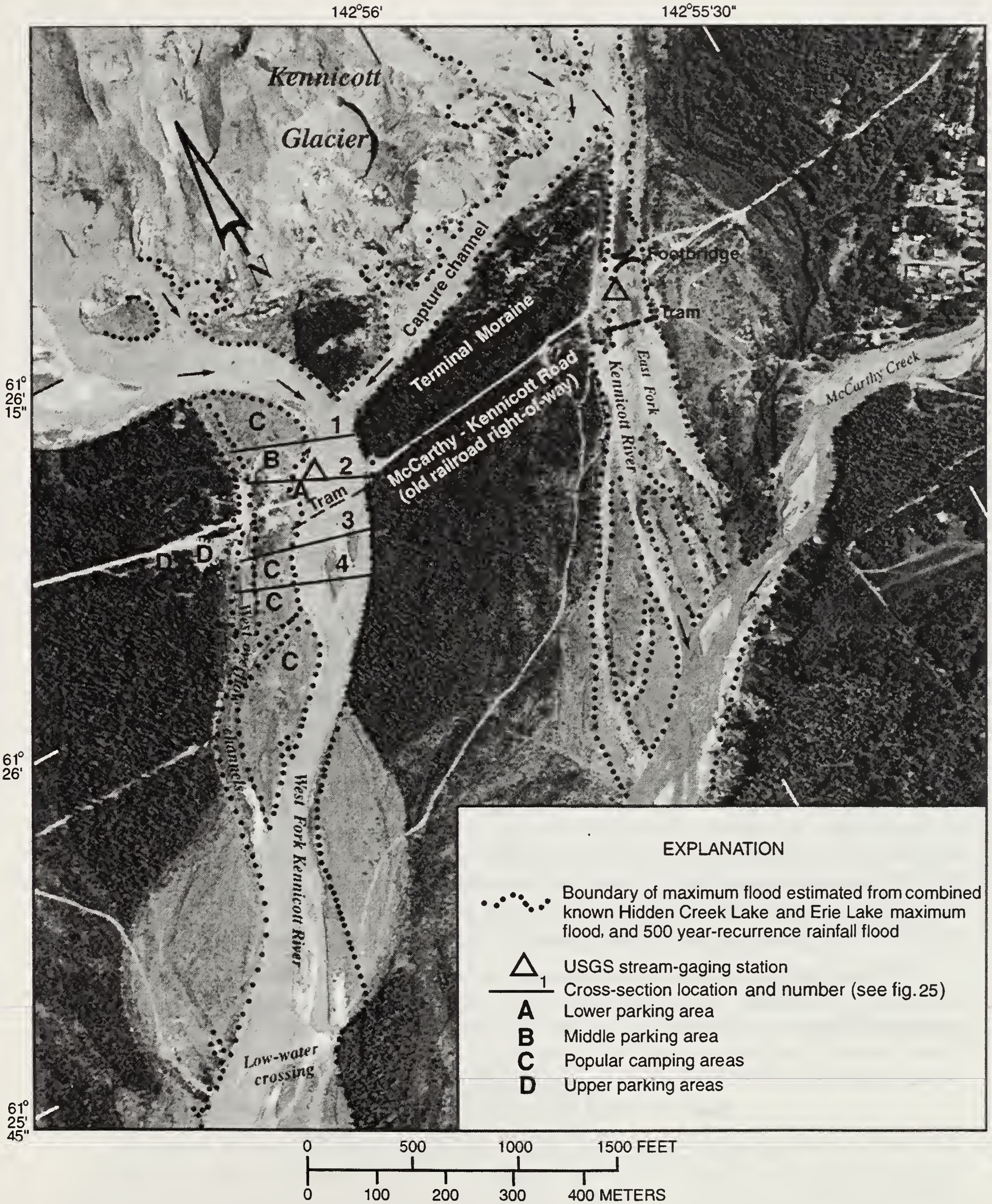



**Figure 26.** Kennicott Glacier terminus and Kennicott River at McCarthy, Alaska, June 14, 1994. (Aerial photograph from Aeromap.)

and Esch, 1977). No obvious correlation exists between aufeis and the rainfall of the previous summer or between aufeis and the winter severity as measured by cumulative freezing degree-days (Ashton, 1986, p. 300).

Snowpack in much of the Copper River Basin—which includes the Kennicott River Basin—was near record low water content as of February 1, 1996 (Natural Resources Conservation Service, 1996). A 6- to 8-foot-thick layer of aufeis formed during the 1995-96 winter in the West Fork Kennicott River. It extended from west lake/hole 2 (which issues water throughout the winter) to cross-section 4 downstream from the tram (fig. 26). Stream water was forced into the west overflow channels throughout the winter. Overflow channel erosion, however, was slight.

## HYDROLOGIC HAZARDS

The Kennicott River Basin is prone to several natural hydrologic hazards including flooding from snowmelt or rainfall, glacier-dammed lake outburst flooding, stream erosion and sediment aggradation, and aufeis.

### Flood Characteristics, 1991 to 1995

Numerous outburst floods, englacial or subglacial releases, and rainfall events (fig. 23) were recorded or observed at the West Fork Kennicott River stream-gaging station. Selected flood peak characteristics are presented in table 6.

The largest floods are caused by rapid draining of Hidden Creek Lake. The lower parking area and a small overflow channel west of the main West Fork Kennicott River channel conveyed some flow during the 1994 and 1995 Hidden Creek Lake floods.The data in table 6 show a noticeable gradual rise in river stage in the days prior to the Hidden Creek Lake outburst. This gradual rise ranged from 2 days in 1995 to 6 days in 1994. Analysis of stage hydrographs (fig. 23) shows other periods in which gradual stage rise occurred; therefore, a gradual stage rise is not an independent predictor of outburst floods. However, the stage of Hidden Creek Lake gradually declines a few days before the outburst. These observations used together may be a good tool to indicate imminent flood danger. Gradual stage rise, ranging from 0.5 to 3 days, in the West Fork Kennicott River also occurred immediately prior to Erie Lake outburst floods. Numerous "spike" peaks (less than 6 hours duration), probably caused by englacial or subglacial releases, occurred during 1992 and 1993. There were few or no gradual changes in stage prior to these releases.

The summary below shows that the duration of floods from the Hidden Creek Lake outburst is not directly dependent on the magnitude of the peak discharge, but controlled by the internal drainage of Kennicott Glacier:

| Date | Maximum discharge West Fork Kennicott River (cubic feet per second) | Duration of flood (hours) |
|---|---|---|
| 7-7-92 | 23,200 | 42 |
| 7-6-93 | 13,500 | 47 |
| 7-29-94 | 28,800 | 44 |

**Table 6.** Selected flood peak characteristics for the West Fork Kennicott River, 1991-95

| Hydrologic event | Date of peak | Number of days of gradual stage rise[1] | Duration of main peak (hours) | Maximum rate of rise (feet per hour) | Change in stage from base to peak (feet) |
|---|---|---|---|---|---|
| Spike peak[2] | June 1, 1991 | 0 | 5 | 0.5 | 1.1 |
| Outburst, Erie Lake | June 23, 1992 | 2 | Unknown | Unknown | Unknown |
| Spike peak | July 1, 1992 | 0 | 3 | 0.3 | 0.3 |
| Outburst, Hidden Creek Lake | July 7, 1992 | 4.5 | 42 | 0.2 | 3.0 |
| Spike peak[2] | July 17, 1992 | 0 | 1 | 7.2 | 1.2 |
| Spike peak[2] | July 25, 1992 | 1 | 1.5 | 7.2 | 1.4 |
| Spike peak[2] | Aug. 15, 1992 | 0 | 3 | 5 | 1.0 |
| Spike peak[2] | June 6, 1993 | 0 | 1.5 | 0.8 | 0.8 |
| Spike peak[2] | June 9, 1993 | 0 | 1 | 0.7 | 0.4 |
| Outburst, Hidden Creek Lake | July 6, 1993 | 4 | 47 | 0.2 | 1.4 |
| Outburst, Erie Lake | July 13, 1993 | 1 | 30 | 0.7 | 0.6 |
| Rainfall | Sept. 3, 1993 | 4 | 140 | 0.03 | 0.8 |
| Outburst, Erie Lake | July 16, 1994 | 3 | 15 | 0.05 | 0.5 |
| Outburst, Hidden Creek Lake | July 29, 1994 | 6 | 44 | 0.8 | 4.4 |
| Rainfall | Aug. 7, 1994 | Undefined | 160 | 0.1 | 1.5 |
| Outburst, Hidden Creek Lake | July 23, 1995 | 2 | 43 | 0.4 | 3.4 |
| Outburst, Erie Lake | Aug. 3, 1995 | 0.5 | 36 | 0.04 | 0.4 |
| Rainfall | Sept. 23, 1995 | 0.7 | 50 | 0.13 | 1.0 |

[1]Prior to rapid stage rise
[2]The short duration (less than 6 hours) spike peaks are probably caused by englacial or subglacial release

Durations of Erie Lake floods were highly variable, suggesting that the rate of lake draining is highly variable. Durations of spike peaks ranged from 1 to 5 hours. Durations of rainfall peaks were long (50 to 160 hours) compared with other events, probably because of long rainfall durations, and travel time of water from various points in the Kennicott basin.

The maximum rate of rise occurred with the spike peaks. The overall stage rise was small (0.3 to 1.4 ft), but sufficient to cause flooding in the lower parking area. However, the rise occurred so quickly and unpredictably that no flood warning might have been possible. Rate of rise for Hidden Creek Lake and Erie Lake outburst floods and rainfall events were more gradual, allowing more time to evacuate flood-prone areas. No changes in stage from spike peaks were observed on the

East Fork Kennicott River; however, spike peaks may have occurred that were not witnessed. Peak stages for the East Fork Kennicott River also occurred during Hidden Creek Lake outburst floods. Not enough data are available to determine whether a gradual rise in stage occurred before these floods. If the West Fork Kennicott River continues to carry a large percentage of the flow from Kennicott Glacier, it will be unlikely that gradual stage rises will occur on the East Fork Kennicott River. The East Fork will probably remain dry, or nearly dry immediately prior to the flood.

### Potential Flood Magnitudes

The magnitudes of future floods in the Kennicott River may be significantly greater than those observed in 1986 (Friend, 1988) and from 1991 through 1995. If Erie Lake and Hidden Creek Lake drain simultaneously, the flood peak could be larger than those observed during this study period. A worst-case scenario would be simultaneous draining of Hidden Creek and Erie Lake coupled with a large rainfall. Potential flood magnitude for the combined flow of both forks of the Kennicott River can be estimated using existing discharge data for the Hidden Creek and Erie Lake outburst floods, and large regional floods estimated using regional flood-frequency equations (Jones and Fahl, 1994).

The recurrence interval is the average number of years within which a flood of a given magnitude will be equaled or exceeded. The frequency of a flood may also be stated in terms of probability of occurrence, which for large floods is the reciprocal of the recurrence interval. For example, a flood with a 50-year recurrence interval ($Q_{50}$) would have a probability of 0.02 or a 2 percent chance of being exceeded in any given year. The following flood-frequency equations were used to calculate the regional flood component. These equations, developed by Jones and Fahl (1994), used a regional multiple regression analysis of 109 peak-flow stations located over much of interior Alaska. They did not include a glacier component; however, many of the sites used to develop the equations were located in glaciated basins.

$$Q_{50} = 147A^{0.778}P^{0.544}(ST+1)^{-0.187}E^{-0.264}$$

$$Q_{100} = 185A^{0.765}P^{0.509}(ST+1)^{-0.179}E^{-0.257}$$

$$Q_{200} = 224A^{0.754}P^{0.480}(ST+1)^{-0.171}E^{-0.252}$$

$$Q_{500} = 275A^{0.742}P^{0.451}(ST+1)^{-0.160}E^{-0.245}$$

where A is the drainage area in square miles (352 $mi^2$ for combined East and West Forks);

P is mean annual precipitation, in inches (75 in. for the Kennicott basin; Jones and Fahl, 1994);

ST is the area of lakes in ponds, in percent (less than 1 percent for the Kennicott basin); and

E is the mean basin elevation, in feet (NGVD of 1929) (5,170 ft for the Kennicott basin).

The calculated combined peak discharges for the East and West Forks Kennicott River at various recurrence intervals, as well as the range of standard error of prediction are listed in table 7.

**Table 7.** Flood magnitude at 50-, 100-, 200- and 500-year recurrence intervals, and corresponding range of standard error of prediction.

| Recurrence interval (years) | $Q_{regional}$ Flood discharge from regression equations (cubic feet per second) | Range of standard error of prediction (percent) |
|---|---|---|
| $Q_{50}$ | 15,400 | -42 to 70 |
| $Q_{100}$ | 16,400 | -44 to 80 |
| $Q_{200}$ | 17,200 | -47 to 87 |
| $Q_{500}$ | 18,400 | -49 to 98 |

The difference between the calculated values for $Q_{50}$ and $Q_{500}$ is only 3,000 $ft^3/s$. Additionally, there is unquantifiable uncertainty in the magnitude of the lake outburst discharges and the gage stage-discharge rating error. The step-backwater model assumes a stable channel, which is not the case for the Kennicott River channel. Because of these uncertainties, a large regional flood of 18,000 $ft^3/s$ was assumed for assessing hazard potential.

The combined discharge ($Q_c$) from the Hidden Creek and Erie Lake outbursts, and a large regional flood is estimated as follows:

$$Q_c = Q_{hcl\text{ - }baseflow} + Q_{el\text{ - }baseflow} + Q_{regional}$$

where $Q_{hcl\text{ - }baseflow}$ is the maximum observed discharge peak from the Hidden Creek Lake outburst floods minus the baseflow (both forks combined);

$Q_{el\text{ - }baseflow}$ is the maximum observed discharge peak from the Erie Lake outburst floods minus baseflow (both forks combined); and

$Q_{regional}$ is a large regional flood estimated using regression equations.

The baseflow component of the Hidden Creek Lake and Erie Lake outburst floods must be subtracted out because $Q_{regional}$ already includes the baseflow component for both East and West Fork Kennicott River. $Q_c$ was determined by using the maximum flood discharge data from tables 5 and 7, and baseflow calculated from a hydrograph separation method that projects pre-peak baseflow across to the recession limb of the hydrograph at $N$ days from the peak, where $N = A^{0.2}$ and A is the drainage area in square miles (Dunne and Leopold, 1978, p. 288). Baseflows used in this calculation were 7,000 $ft^3/s$ for the Erie Lake flood, and 5,400 $ft^3/s$ for the Hidden Creek Lake flood.

$Q_c$ = 31,900 $ft^3/s$ ($Q_{hcl,}$ July 29, 1994) - 5,400 $ft^3/s$ (baseflow) + 10,800 $ft^3/s$ ($Q_{el}$, July 13, 1993) - 7,000 $ft^3/s$ (baseflow) + 18,000 $ft^3/s$ ($Q_{regional}$) = 48,300 $ft^3/s$.

## Hazard Potentials

If the West Fork Kennicott River captures all the flow from the East Fork Kennicott River—as the present trend suggests will happen— the potential peak stage for combined Hidden Creek Lake and Erie Lake outbursts and regional floods can be estimated for the present channel geometry using step-backwater calculations (Shearman and others, 1986). Using an assumed combined discharge of 48,300 $ft^3/s$, maximum stage was calculated at four cross sections on the West Fork: two upstream from the tram, and two downstream (figs. 26 and 27).

Peak stages for the 1994 Hidden Creek Lake outburst flood are also plotted in figure 27. The 1994 flood was at **bankfull stage** for the main channel, with a minor quantity of overflow into the west overflow channel. A flood of 48,300 $ft^3/s$ would cause sufficient flow in the west overflow channel to block access to or from the lower parking area (fig. 26). The area on the West Fork Kennicott River that would be submerged during the peak is shown in figure 26. If east lake/hole 4 and west lake/hole 2 continue to migrate up-glacier, sharper and higher discharge peaks may occur because of more efficient internal glacial drainage.

It is assumed that the East Fork Kennicott River as shown in figure 26 will continue to convey flood water in the near future. This hazard will diminish if the present trend of flow capture by the West Fork Kennicott River continues. The parts of the glacier terminus delineated as "flood hazard areas" are based on cross-section surveys and peak-flow observations made during the 1994 and 1995 outburst floods and on the boundary of the maximum evident outburst flood (Jones and Glass, 1993).

It is likely that the channel of the West Fork Kennicott River will continue to be unstable; this channel has been downcutting (fig. 24; fig. 25, cross sections 1 and 2). It is neither possible to predict if this trend will continue nor possible to determine if the channel will aggrade during flood-peak recessions. The tremendous volume of alluvial material on the lower part of Kennicott Glacier could cause channel aggradation. If this occurs, a larger area would be inundated and lateral migration of the channel might occur.

Lateral channel migration has occurred in the past (figs. 16 and 17), in response to thinning and retreat of the Kennicott Glacier terminus, and will likely continue in the future. Geomorphic evolution of the glacier and observations made in 1994 and 1995 suggest that the following scenario is likely to occur in the terminus outwash region (fig. 28).

Channels along the eastern margin of Kennicott Glacier will migrate westward. This migration may occur in a series of small steps or catastrophically during a flood. Future channel positions are depicted at times arbitrarily labeled "T1, T2, T3, and T4" (fig. 28). T1 through T3 are considered "probable" based on flow pattern observations made between 1991 and 1995. T4 is considered "possible," but depends on exact changes depicted with T1 through T3. The speed at which these changes occur depends on the magnitude of the outburst flood and on climatological conditions. At time T1, the channel position is expected to be approximately half way to the current confluence area. This will be followed by T2 and T3 channel positions farther to the west.

Water along the western margin of Kennicott Glacier is expected to bypass the existing channel and jump towards the center (time T2) of the valley. When this occurs, water issuing from west lake/hole 3 (fig. 19) will join with and pass directly through the west lake/hole 2 area (fig. 29). Eventually, all channels will merge to T4, and the confluence will migrate up-glacier. Changes in the glacier and outwash area will result in continued channel migration in the transportation corridor. Changes in englacial or subglacial drainage may cause glacier-dammed lakes to drain more rapidly, which would result in sharper, higher flood peaks (Shreve, 1972; Hooke, 1989).

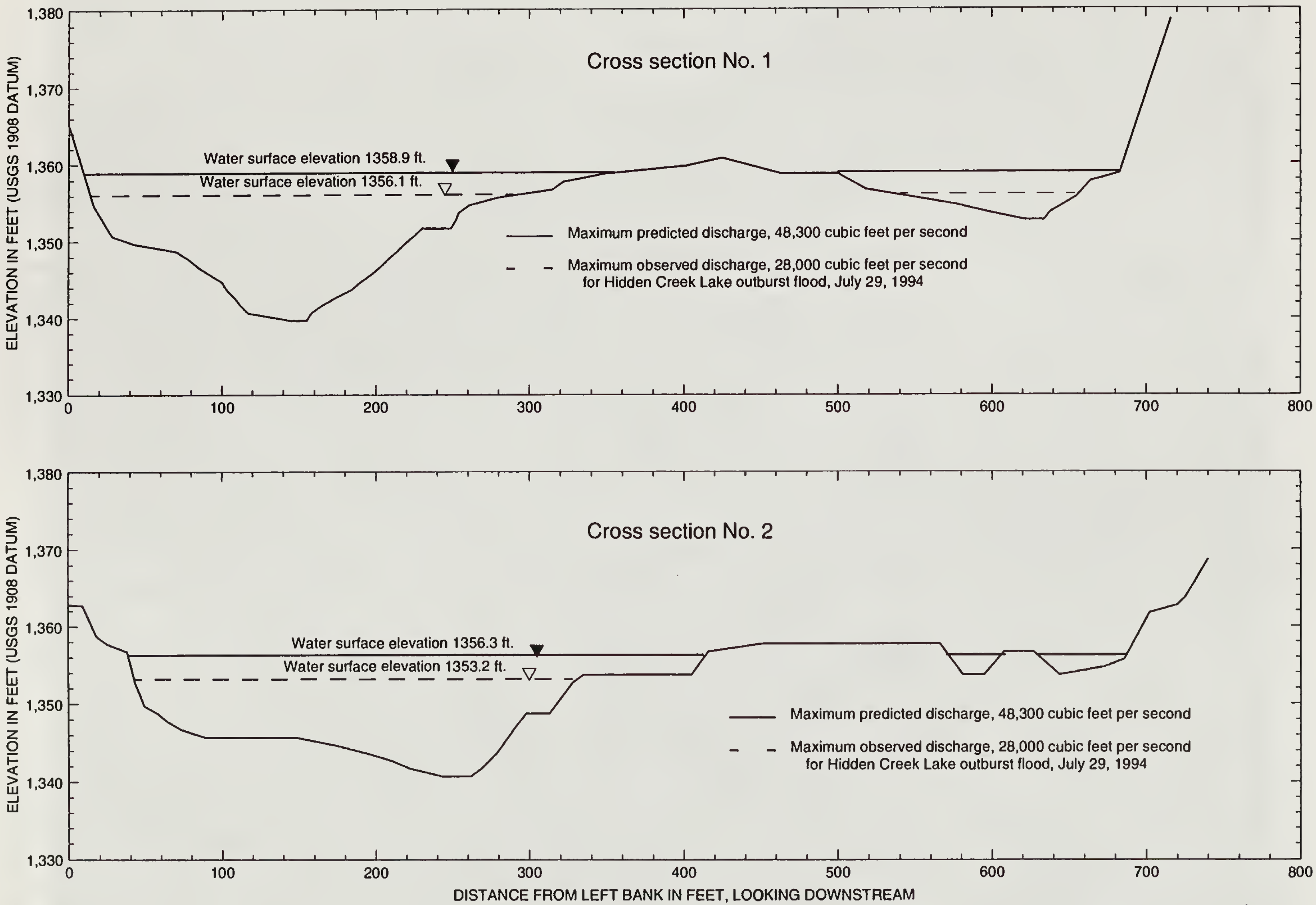



**Figure 27.** Water-surface elevations for maximum observed and maximum predicted discharges for the West Fork Kennicott River (see figure 26 for cross-section locations).

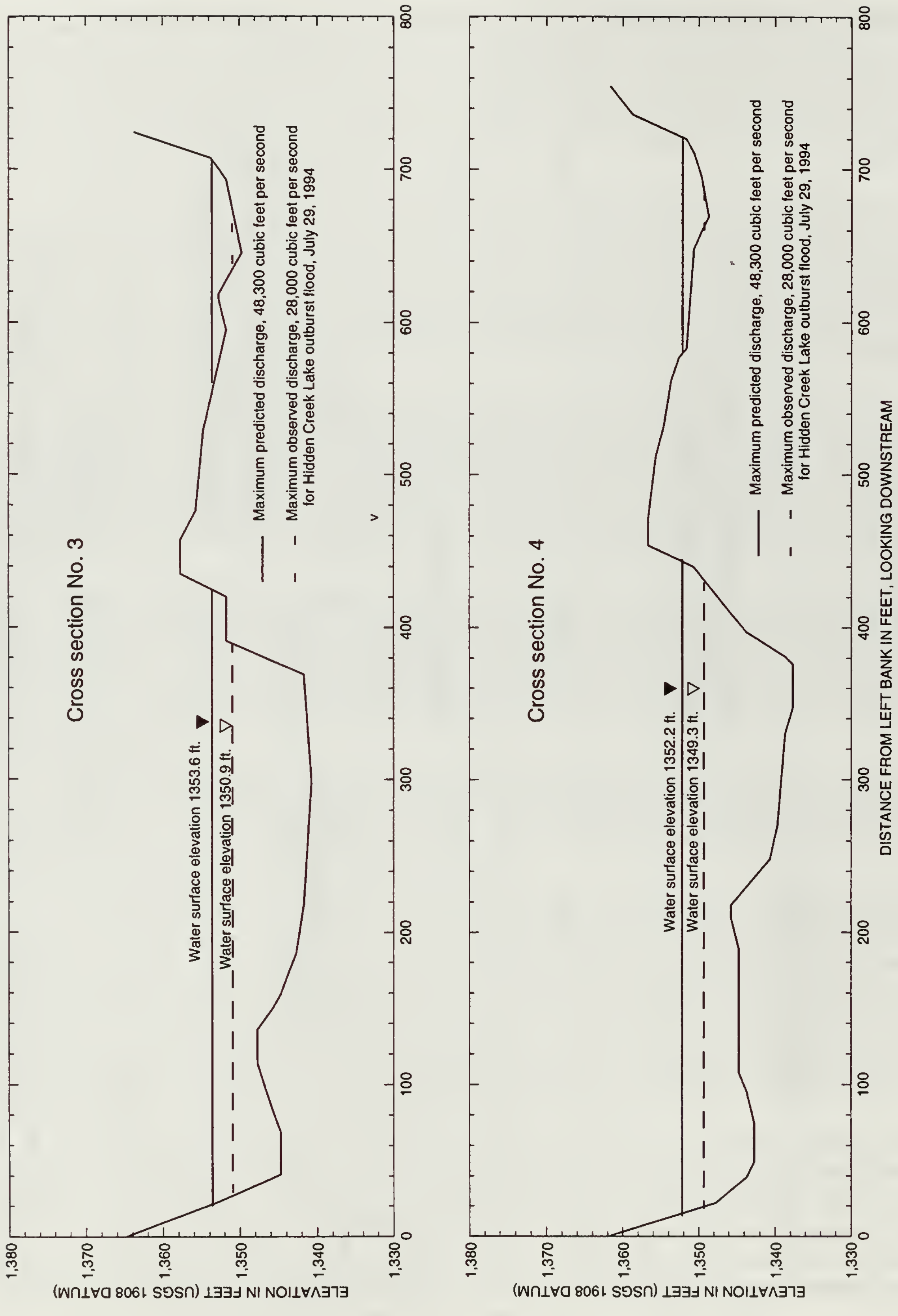



**Figure 27.** Continued.

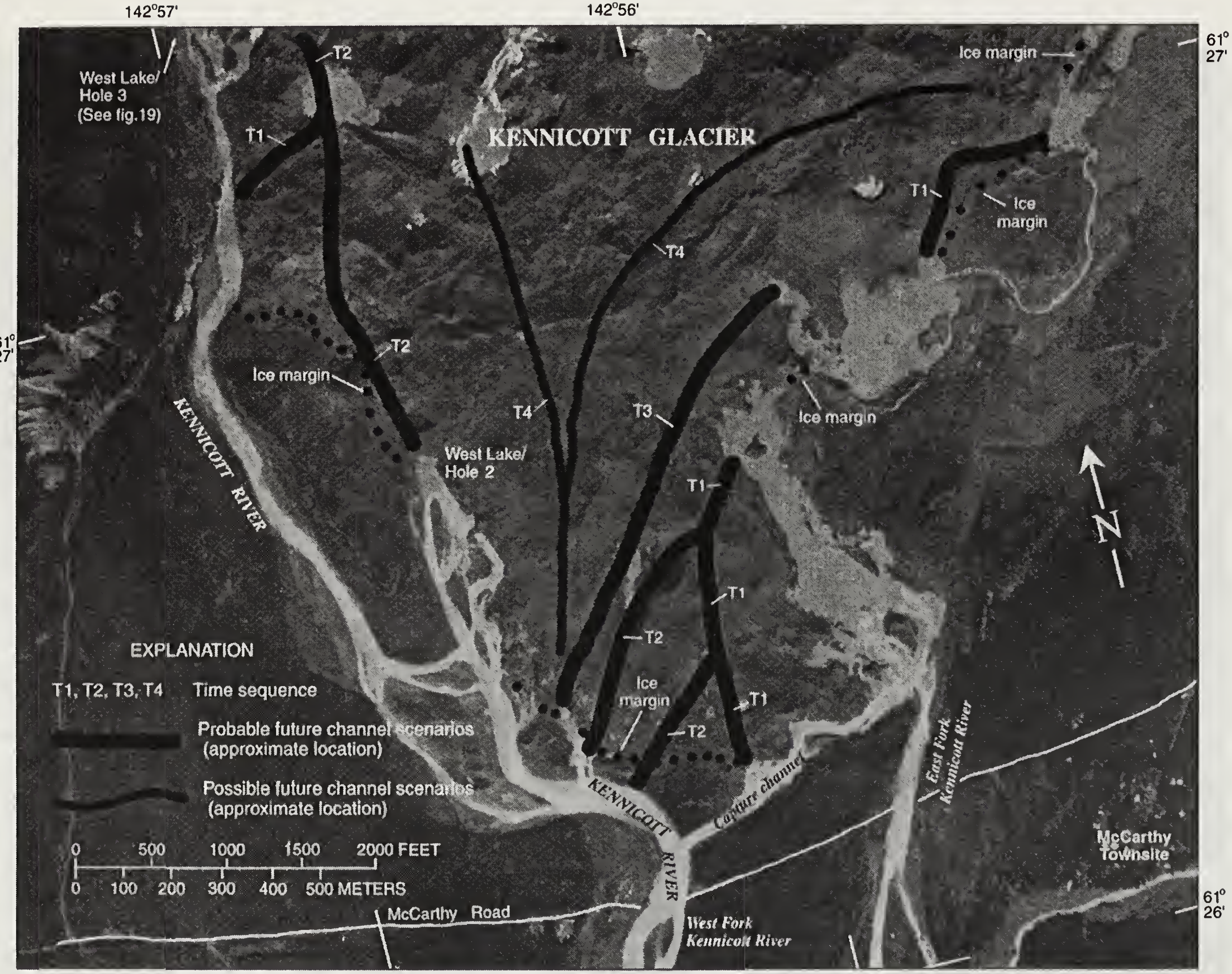



**Figure 28.** Kennicott Glacier and outwash, and future drainage scenario for the Kennicott River. (Aerial photograph base map, August 22, 1990.)


**Figure 29.** Kennicott Glacier terminus, July 23, 1995. (View is to southeast.)

Aufeis formation may block normal drainage channels and force water into alternate channels, such as the western overflow channels (fig. 26), causing erosion and channel migration. Large aufeis deposits may encroach on the lower parking areas and damage structures. If aufeis deposits move during breakup, the extra thickness can impose large ice loads on bridge piers (Ashton, 1986, p. 301).

## FUTURE STUDIES

The largest floods will probably continue to be those caused by draining of Hidden Creek Lake, or by the combined draining of this lake and Erie Lake, and rainfall. Channel erosion, aggradation, and migration are also a hazard. The following efforts may aid in monitoring pre-flood conditions, and help predict future channel changes.

1. Periodic surveying of the geomorphic profiles (fig. 21) across the Kennicott Glacier terminus and the East and West Forks Kennicott River to monitor changes would help to predict future channel migration and flood hazards.
2. Mapping the underlying landforms of Kennicott Glacier from Hidden Creek Lake across to Erie Lake and down to the glacier terminus using ice-penetrating radar would provide valuable insight concerning future channel migration and possible changes of locations where flow issues from Kennicott Glacier.

3. Installing recording stream-gaging stations with satellite telemetry on the East and West Forks Kennicott River would provide near real-time river stage data, which could be used to predict and monitor floods. Making periodic discharge measurements would verify and update the stage-discharge relationships, aid in determining flood magnitudes, verify flood-water capture by the West Fork, and monitor channel changes.
4. Monitoring Hidden Creek Lake could determine when the lake is beginning to drain. Indicators of imminent outburst flooding are (a) stationary or declining lake stage, (b) large ice blocks actively calving off the ice-dam front, (c) formation of a clean ice washline along the ice-dam front or margin, (d) presence of rafted slush ice and small icebergs on the lakeshore, and (e) ice-dam fractures and escarpments. Identifying physical features at the 3,000-foot elevation level along the lakeshore that are easily seen from low-flying aircraft would help predict outbursts. Documenting the dates of the annual Hidden Creek Lake outbursts would help bracket timing of outbursts.
5. Measuring peak lake stage annually from existing control at Hidden Creek Lake would document changes over time.
6. Developing a relation between maximum stage at Hidden Creek Lake and total outburst flood volume would help assess flood hazard potential.

## SUMMARY

Knowledge of hydrologic conditions and hazards is necessary for evaluating proposed activities in the Kennicott River Basin. Hydrologic hazards include rainfall-induced floods; glacier-dammed lake outburst floods; channel erosion, aggradation, and migration; and aufeis formation. Draining of ice-dammed lakes causes the largest floods in the Kennicott basin.

Hidden Creek Lake is the largest glacier-dammed lake in the basin, and drains on an annual basis. The maximum annual lake level is declining with time, and outburst floods in recent years have been occurring at earlier dates than previously documented. The decline in maximum lake level does not necessarily mean that maximum lake volume is decreasing. Annual lake volumes remain unquantified because of changes in the following: ice-dam position, percentage of icebergs, volume of water underlying the glacier between the ice margin and ice dam, and lake basin morphology. The following indicators can be used to forecast imminent draining of Hidden Creek Lake: lake stage near or above the level of recent maximum stages, stationary or declining lake stage, evidence of recent calving of large ice blocks from the ice margin, formation of a "clean ice" washline along the ice margin, slush ice and small icebergs stranded on the lakeshore, and fresh fractures and escarpments in the ice margin region.

Other glacier-dammed lakes in the Kennicott River Basin are Erie, Donoho, Gates, Jumbo, and Bonanza. Outburst floods from Erie Lake—but not from the other lakes—are evident in hydrographs of the Kennicott River. Outburst flood water from Hidden Creek Lake refills Donoho and Jumbo Lakes indicating a complex englacial and subglacial drainage system.

The most recent maximum advance of Kennicott Glacier occurred about 1860. The glacier terminus has retreated 2,000 ft since 1909, and the active stream channel/ice margin has dropped more than 70 ft. As the glacier thins and retreats, a recurring succession—karst, pond, active channel, and abandoned channel—occurs. This succession is most obvious along the southeast margin

where the retreat has been most extensive. Recognizing these four stages in this evolutionary sequence provides a tool for predicting future drainage patterns and assessing potential flood hazards.

Water issues from Kennicott Glacier at several points and forms two main river channels: the West and East Forks Kennicott River. Historical data indicate that outburst floods from Hidden Creek Lake are larger than rainfall-induced floods or floods from other glacier-dammed lake outbursts. The West and East Forks Kennicott River channels are prone to erosion, aggradation, and migration. The most significant channel changes occur during the Hidden Creek Lake outburst floods. The West Fork Kennicott River has downcut 20 ft at the railroad grade since 1911, and is much larger today than it was in 1911. The East Fork Kennicott River has migrated westward, leaving behind abandoned channels, and now carries less flow than it has historically. A capture channel diverts water from the East Fork Kennicott River to the West Fork Kennicott River. The West Fork carries a larger percentage of flood flow each year. If this trend continues, the East Fork channel will eventually be abandoned.

River stage was observed to gradually rise beginning 4 to 6 days prior to the Hidden Creek Lake outburst floods. This observation coupled with evidence of slow draining of Hidden Creek Lake may be useful as a warning tool. Englacial and subglacial releases caused the most rapid stage rises in the Kennicott River; the overall changes in stage are small, but occurred rapidly.

A potential flood magnitude of 48,300 $ft^3/s$ was estimated by combining known maximum discharges from Hidden Creek and Erie Lake outburst floods with a large regional flood. The flood hazard zone in the transportation corridor was delineated using channel geometry surveyed in October 1994. Channel erosion or aggradation may increase or decrease the size of the flood hazard zone.

As Kennicott Glacier continues to thin and retreat, the inner glacier drainage may become more efficient, possibly leading to sharper and higher flood peaks. Aufeis formation may cause channel and bank erosion and may damage bridge piers and structures near the Kennicott River.

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## GLOSSARY

**Ablation.** The combined processes of melt, runoff,and evaporation by which a glacier loses mass.

**Alluvium.** A general term for all detrital deposits resulting from the operations of river, including sediments laid down in riverbeds, flood plains, fans, and at the foot of mountains.

**Arcuate.** Bent or curved in the form of a bow.

**Aufeis**. A mass of ice that forms by overflow and subsequent freezing of sheets of surface water or emerging ground water.

**Bankfull stage.** The stage at which the channel just begins to overflow the flood plain (Hedman and Osterkamp, 1982, p. 4). The reference level for this section (bankfull stage) is variously defined by breaks in bank slope, by the edges of the flood plain, or the lower limits of permanent vegetation.

**Dacite**. A fine-grained extrusive rock.

**Dropstone**. An oversized stone in laminated sediment that depresses the underlying laminae and may be covered by "draped" laminae. Most dropstones originate through ice-rafting.

**En echelon.** In an overlapping or staggered arrangement.

**Englacial.** Within glacier ice.

**Glacial erratic.** A rock fragment carried by a glacier and deposited at some distance from the outcrop from which it was derived.

**Karst.** As used in this report, karst refers to the portion of glaciers characterized by closed depressions, sinkholes, caves, and under-glacier drainage.

**Lake/hole.** As used in this report, lake/hole refers to a point where water issues from the glacier margin, or at one time did issue, from the glacier. When occupied with water, a lake is formed; when drained, a dry hole is left.

**Moraine.** Drift deposited chiefly by direct glacial action and having constructional topography independent of control by the surface on which the drift lies.

**Outburst flood**. A sudden, often annual, outburst of water from a glacier or glacier-dammed lake, sometimes resulting in a catastrophic flood.

**Plastic deformation.** Permanent deformation of the shape or volume of a substance, without rupture.

**Pothole.** As used in this report, pothole refers to the historical main point of issue for outburst flood water. Water "boiled out of these holes during outburst flooding," according to historical records.

**Sinkhole**. As used in this report, a circular depression, commonly funnel shaped, on the karst portion of the glacier. Drainage is englacial or subglacial.

**Slope-area method.** Method for computing water discharge using Manning equation for conditions of uniform flow in which the water-surface profile and energy gradient are parallel to the streambed, and the area, hydraulic radius, and depth remain constant throughout the reach.

**Step-backwater method.** Method for computing water-surface profiles using the energy equation in a series of subreaches for conditions of steady uniform flow in which the flow at both end cross sections is either all supercritical or all subcritical, the slope is small enough so that normal depth can be considered to be vertical depth, and the water surface across the cross section is level.

**Strandline.** Horizontal terrace, formed by wave action, that marks previous lake stages.

**Subglacial.** Beneath glacier ice.

**Supraglacial**. On the glacier surface.

**Thalweg.** Line joining the deepest points of a stream channel.

**Trim line.** Line marking the former margin of a glacier.

# APPENDIX 1

Summary of historical data and references for Hidden Creek Lake

HIDDEN CREEK LAKE GRAPH DATA [PS(M), estimated or measured peak stage, in meters; EPS(FT), estimated peak stage, in feet; MPS(FT), measured peak stage, in feet]

| SITE | YEAR | MONTH | DAY | DD-MMM | DATE | STATUS | NOTES | SOURCE | S_NOTES | PS(M) | EPS(FT) | MPS(FT) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HIDDEN CRK LK | 1900 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1901 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1902 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1903 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1904 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1905 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1906 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1907 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1908 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1909 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1910 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1911 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1912 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1913 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1914 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1915 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1916 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1917 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1918 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1919 | 6 | 25 | 175 | 06/25/19 | FILLING | YEAR/DATE?,STAGE>94,DATE EST @ L.JUNE | PHOTO | PRE-1938 PHOTO,E.HOLLARD-KENNECOTT,KID | 924.5 | | 3033 |
| HIDDEN CRK LK | 1920 | 7 | 20 | 201 | 07/20/20 | FILLING | YEAR/DATE?,STAGE>94,DATE EST @M/L.JULY | PHOTO | PRE-1938 PHOTO,C.HODGES-KENNECOTT,KID | 934.6 | | 3066 |
| HIDDEN CRK LK | 1921 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1922 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1923 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1924 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1925 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1926 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1927 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1928 | 6 | 16 | 166 | 06/16/28 | FILLING | SKETCH FIELD NOTES, WATER LEVEL DEPICTED | USGS | F. MOFFIT FIELD NOTES, BK#839 P105 | | | |
| HIDDEN CRK LK | 1929 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1930 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1931 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1932 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1933 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1934 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1935 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1936 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1937 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1938 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1939 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1940 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1941 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1942 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1943 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1944 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1945 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1946 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1947 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1948 | 6 | 18 | 169 | 06/18/48 | FILLING | ICEBERS & SLUSH NEAR GLACIER | PHOTO | TRIMET#241RT-72PL-C-6M164-72RS-18JUNE48-ACR-1B | | | |
| HIDDEN CRK LK | 1949 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1950 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1951 | 7 | 10 | 191 | 07/10/51 | FILLING | STAGE DEPICTED, 1950? PERCHED BERGS | PHOTO | ALASKA ICE-DAMMED LAKES, K. STONE, 1963 | 922.3 | | 3026 |
| HIDDEN CRK LK | 1952 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1953 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1954 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1955 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1956 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1957 | 8 | 1 | 213 | 08/01/57 | FILLING | APPRX DATE, HIGHEST KNOWN STAGE | PHOTO | A.POST, 4.11 AUG, 1957 | | | |
| HIDDEN CRK LK | 1958 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1959 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1960 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1961 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1962 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1963 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1964 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1965 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1966 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1967 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1968 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1969 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1970 | | | | | FILLING | | | | | | |

# HIDDEN CREEK LAKE GRAPH DATA

| | | | | | | | | | | PS(M) | EPS(FT) | MPS(FT) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HIDDEN CRK LK | 1971 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1972 | 7 | 21 | 202 | 07/21/72 | FILLING | STAGE REACHES/EXCEEDS WILLOW RM | PHOTO | NASA/JCS,M#209,FL#24-81,COL(#23-81,CIR) | 924.3 | | 3033 |
| HIDDEN CRK LK | 1973 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1974 | 8 | 11 | 223 | 08/11/74 | FILLING | LAKE LEVEL DEPICTED | SLIDE | G.WINLKER, USGS | | | |
| HIDDEN CRK LK | 1975 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1976 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1977 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1978 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1979 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1980 | 8 | 7 | 219 | 08/07/80 | FILLING | PRE-RELEASE??, FOOT BRIDGE STANDING | OBSERVATION | E. LACHAPELLE BRIDGE STANDING, PER COMM. | | | |
| HIDDEN CRK LK | 1981 | 7 | 1 | 182 | 07/01/81 | FILLING | PRE-RELEASE, FOOT BRIDGE STANDING | J. HANNAH | BRIDGE STANDING, PER. COMM | | | |
| HIDDEN CRK LK | 1982 | 7 | 6 | 187 | 07/06/82 | FILLING | APPEARS FULL | PHOTO | OBLIUQE, NPS:WASO-MMB 1983 RPT | | | |
| HIDDEN CRK LK | 1983 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1984 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1985 | 7 | 27 | 208 | 07/27/85 | FILLING | LARGE LAKE | TM IMAGE | LANDSAT PATH 65, ROW 7 | | | |
| HIDDEN CRK LK | 1986 | 7 | 27 | 208 | 07/27/86 | FILLING | LAKE LEVEL VISIBLE | PHOTO | NPS, L. HOVIS FIELD SURVEY OF SITE | | | |
| HIDDEN CRK LK | 1987 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1988 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1989 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1990 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1991 | | | | | FILLING | | | | | | |
| HIDDEN CRK LK | 1992 | 7 | 2 | 183 | 07/02/92 | FILLING | WATER LEVEL TO ROCK GL, PLOT H2O LEVEL | SLIDE | ROSENKRANS, DATE WITHIN 1 or 2 days | | | |
| HIDDEN CRK LK | 1993 | 6 | 24 | 174 | 06/24/93 | FILLING | WATER LEVEL NEAR ROCK GL, PLOT H2O LEVEL | PRINTS (2) | ROSENKRANS | 912.8 | | 2995 |
| HIDDEN CRK LK | 1994 | 7 | 18 | 197 | 07/18/94 | FILLING | 09:15, -2M WASHLINE ON GLACIER | REPORT | R. ELCONIN, AERIAL OBSERVATION | | | |
| HIDDEN CRK LK | 1995 | 7 | 20 | 201 | 07/20/95 | FILLING | LAKE STAGE INCREASING | PHOTO | TIME LAPSE CAMERA | | | |
| HIDDEN CRK LK | 1860 | | | | | OUTBURST | HIGHEST CONTINOUS STRANDLINE, CIRCA 1860? | SURVEY | USGS FIELD SURVEY, NUMEROUS SPOT EL. | 960.8 | 3152 | |
| HIDDEN CRK LK | 1861 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1862 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1863 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1864 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1865 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1866 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1867 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1868 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1869 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1870 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1871 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1872 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1873 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1874 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1875 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1876 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1877 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1878 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1879 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1880 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1881 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1882 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1883 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1884 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1885 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1886 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1887 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1888 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1889 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1890 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1891 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1892 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1893 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1894 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1895 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1896 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1897 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1898 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1899 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1900 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1901 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1902 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1903 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1904 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1905 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1906 | | | | | OUTBURST | | | | | | |

HIDDEN CREEK LAKE GRAPH DATA

| | | | | | | | | | | PS(M) | EPS(FT) | MPS(FT) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HIDDEN CRK LK | 1979 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1980 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1981 | 7 | 19 | 200 | 07/19/81 | OUTBURST | FLOOD OBSERVED AND BRIDGE COLLAPSED | PHOTO | G. GREENE, PER. COMM AND PHOTO JUL/81 | | | |
| HIDDEN CRK LK | 1982 | | | | | OUTBURST | | | | 922.2 | 3026 | |
| HIDDEN CRK LK | 1983 | 8 | 7 | 219 | 08/07/83 | OUTBURST | FLOOD EVENT OBSERVED, EARLY IN MONTH | R. ELLIOT | OBSERVATION,PER. COMM. (VERBAL) | | | |
| HIDDEN CRK LK | 1984 | 8 | 28 | 238 | 08/26/84 | OUTBURST | FLOOD EVENT, CONFLICTING REPORTS | NOTES | WMC DATA, B. HECHT .COMM (VERBAL-DEFINATE) | 921.7 | | 3024 |
| HIDDEN CRK LK | 1985 | 8 | 16 | 228 | 08/16/85 | OUTBURST | BIG FLOOD, CLEAR CRK 1M DEEP W/RAINS | NOTES | D. DOAK, PER COMM (LETTER) | | | |
| HIDDEN CRK LK | 1986 | 8 | 8 | 218 | 08/06/86 | OUTBURST | PEAK STAGE RECORDED ON 1974 AERIAL PHOTO | FRIEND | MS THESIS & PER. CONVERSATION | 915.8 | 3005 | |
| HIDDEN CRK LK | 1987 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1988 | 7 | 23 | 204 | 07/23/88 | OUTBURST | EVENT OBSERVED IN MCCARTHY | NOTES | B. HECHT, PER COMM. | | | |
| HIDDEN CRK LK | 1989 | 7 | 19 | 200 | 07/19/89 | OUTBURST | RIVER VERY HIGH | NOTES | D. DOAK, PER COMM. (LETTER) | | | |
| HIDDEN CRK LK | 1990 | 7 | 4 | 185 | 07/04/90 | OUTBURST | | USGS | DRAFT REPORT,JONES, TABLE #2 | 916.1 | | 3006 |
| HIDDEN CRK LK | 1991 | 8 | 3 | 215 | 08/03/91 | OUTBURST | | USGS | DRAFT REPORT STAN JONES TABLE #2 | | | |
| HIDDEN CRK LK | 1992 | 7 | 6 | 187 | 07/06/92 | OUTBURST | 50% VOLUME,STRANDED BERGS,PEAK 92 STAGE | PHOTO | G. GREEN DATED PHOTO | 915.1 | 3002 | |
| HIDDEN CRK LK | 1993 | 7 | 5 | 186 | 07/05/93 | OUTBURST | PEAK DISCHARGE AT TRAM 7/6/93 | STAGE GAGE | USGS STAGE RECORD AT KENNICOTT TRAM | 912.8 | | 2995 |
| HIDDEN CRK LK | 1994 | 7 | 29 | 210 | 07/29/94 | OUTBURST | OUTBURST EVENT 10:00 AM STAGE DOWN 35'? | PHOTO | AERIAL OBSERVATION, ROSENKRANS | 920.8 | 3021 | |
| HIDDEN CRK LK | 1995 | 7 | 23 | 204 | 07/23/95 | OUTBURST | WATERLEVEL @ TOP TERMINAL MORAINE 9.00 | PHOTO | ROSENKRANS, AERIAL OBSERVATION & NOTES | 918.1 | 3006 | |
| HIDDEN CRK LK | 1900 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1901 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1902 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1903 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1904 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1905 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1906 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1907 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1908 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1909 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1910 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1911 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1912 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1913 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1914 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1915 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1916 | 9 | 12 | 255 | 09/12/18 | POST/OUTB | STRANDED BERGS, STRANDLINE VISIBLE | USGS | F. MOFFIT, BULL #894 PLATE #5A | | | |
| HIDDEN CRK LK | 1917 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1918 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1919 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1920 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1921 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1922 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1923 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1924 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1925 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1926 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1927 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1928 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1929 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1930 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1931 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1932 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1933 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1934 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1935 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1936 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1937 | 8 | 14 | 228 | 08/14/37 | POST/OUTB | ICE DAM FRACTURES @ MARGIN OF PHOTO | PHOTO | B. WASHBURN, #570 | | | |
| HIDDEN CRK LK | 1938 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1939 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1940 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1941 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1942 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1943 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1944 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1945 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1946 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1947 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1948 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1949 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1950 | | | | | POST/OUTB | 1950? PERCHED BERGS DEPICTED IN 1951 PHOTO | PHOTO | ALASKA ICE-DAMMED LAKES ,K.STONE, 1963 | 929.8 | | 3051 |
| HIDDEN CRK LK | 1951 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1952 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1953 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1954 | | | | | POST/OUTB | | | | | | |

# HIDDEN CREEK LAKE GRAPH DATA

| | | | | | | | | | | PS(M) | EPS(FT) | MPS(FT) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HIDDEN CRK LK | 1907 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1908 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1909 | | | | | OUTBURST | POTHOLE RELEASED EARLY IN 1909 | USGS | USGS BULL #448 PAGE 14 | | | |
| HIDDEN CRK LK | 1910 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1911 | 9 | 15 | 258 | 09/15/11 | OUTBURST | ICY LK BROKE,BRIDGE DAMAGE,POTHOLE ACTIV | PUBLISHED | COPPER SPIKE, PAGE 128 | | | |
| HIDDEN CRK LK | 1912 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1913 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1914 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1915 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1916 | | | | | OUTBURST | | | | 945.9 | 3103 | |
| HIDDEN CRK LK | 1917 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1918 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1919 | | | | | OUTBURST | | | | 924.5 | | 3033 |
| HIDDEN CRK LK | 1920 | | | | | OUTBURST | | | | 934.8 | | 3066 |
| HIDDEN CRK LK | 1921 | 9 | 16 | 259 | 09/16/21 | OUTBURST | POTHOLE GEYSER 40' HIGH, LESS THAN PAST | PUBLISHED | MCCARTHY WEEKLY NEWS 9/17/21 | | | |
| HIDDEN CRK LK | 1922 | 9 | 2 | 245 | 09/02/22 | OUTBURST | POTHOLE BREAKS 2 WEEKS EARLY | PUBLISHED | MCCARTHY WEEKLY NEWS 9/9/22 | | | |
| HIDDEN CRK LK | 1923 | 8 | 20 | 232 | 08/20/23 | OUTBURST | NEW POTHOLE ATOP GLACIER, DATE EST. (8/18-8/2 | PUBLISHED | MCCARTHY WEEKLY NEWS 8/23/23 | | | |
| HIDDEN CRK LK | 1924 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1925 | 9 | 7 | 250 | 09/07/25 | OUTBURST | BRIDGE DAMAGE, BROKE OUT NUNEROUS PLACE | PUBLISHED | MCCARTHY WEEKLY NEWS 9/12/25 | | | |
| HIDDEN CRK LK | 1926 | 8 | 29 | 241 | 08/29/26 | OUTBURST | BREAKOUT NOT AS SPECTACULAR AS USUAL | PUBLISHED | MCCARTHY WEEKLY NEWS 9/4/26 | | | |
| HIDDEN CRK LK | 1927 | | | | | OUTBURST | USUALLY RELEASED IN AUGUST PRIOR TO 1928 | USGS | BULL #984. F. MOFFIT PLATE 5A | | | |
| HIDDEN CRK LK | 1928 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1929 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1930 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1931 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1932 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1933 | 8 | 28 | 240 | 08/28/33 | OUTBURST | "POTHOLE BROKE, FOOT KENNICOTT GL." | DATABANK | USWB CLIMATE DATA, L. YEHLE | | | |
| HIDDEN CRK LK | 1934 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1935 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1936 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1937 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1938 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1939 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1940 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1941 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1942 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1943 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1944 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1945 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1946 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1947 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1948 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1949 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1950 | | | | | OUTBURST | | | | 928.9 | | 3051 |
| HIDDEN CRK LK | 1951 | | | | | OUTBURST | | | | 922.3 | | 3028 |
| HIDDEN CRK LK | 1952 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1953 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1954 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1955 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1956 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1957 | 8 | 4 | 218 | 08/04/57 | OUTBURST | STRANDLINE,PARTLY DRAINED?,PERCHED BERGS | PHOTO | W. FIELD IGY-RPT, L. VIERECK #LV-57-B151 | 936.1 | 3071 | |
| HIDDEN CRK LK | 1958 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1959 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1960 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1961 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1962 | 8 | 14 | 226 | 08/14/62 | OUTBURST | RELEASE STARTED 8/13 FINISHED 8/14 | PHOTO | L. YEHLE , NOTES AND OBSERVATION | | | |
| HIDDEN CRK LK | 1963 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1964 | | | | | OUTBURST | . | | | 929.9 | | 3051 |
| HIDDEN CRK LK | 1965 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1966 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1967 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1968 | | | | | OUTBURST | FLOOD ON CHITINA R OBSERVED | POST/MAYO | USGS HA-#455, REF. (PER COMM MCKECHNIE) | | | |
| HIDDEN CRK LK | 1969 | | | | | OUTBURST | | | | 923.3 | | 3029 |
| HIDDEN CRK LK | 1970 | | | | | OUTBURST | | | | 925.4 | | 3036 |
| HIDDEN CRK LK | 1971 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1972 | | | | | OUTBURST | | | | 924.3 | | 3033 |
| HIDDEN CRK LK | 1973 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1974 | 8 | 16 | 228 | 08/16/74 | OUTBURST | FLOOD EVENT AND LAKE OBSERVED | PHOTO | G. MULL, SLIDES AND OBSERVATIONS COMM. | 922.8 | 3028 | |
| HIDDEN CRK LK | 1975 | 8 | 6 | 218 | 08/06/75 | OUTBURST | LAKE DRAINING,>50%FULL,STRANDED BERGS | PHOTO | USGS,#75M4-1/2,OBLIQUE,1:20179,B&W | 924.9 | 3035 | |
| HIDDEN CRK LK | 1976 | | | | | OUTBURST | | | | 925.5 | 3037 | |
| HIDDEN CRK LK | 1977 | | | | | OUTBURST | | | | | | |
| HIDDEN CRK LK | 1978 | 8 | 10 | 222 | 08/10/78 | OUTBURST | LARGE FLOOD | J. MILLER | OBSERVATION, VERBAL COMM. | 925.3 | | 3036 |

## HIDDEN CREEK LAKE GRAPH DATA

| | | | | | | | | | | PS(M) | EPS(FT) | MPS(FT) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HIDDEN CRK LK | 1955 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1956 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1957 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1958 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1959 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1960 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1961 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1962 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1963 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1964 | 6 | 24 | 236 | 08/24/64 | POST/OUTB | POST RELEASE, STRANDLINE, | PHOTO | USGS,K842-76, OBLIQUE | 929.9 | | 3051 |
| HIDDEN CRK LK | 1965 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1966 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1967 | 9 | 1 | 244 | 09/01/67 | POST/OUTB | STRANDED BERGS, FALL COLORS, NO SNOW | SLIDE | G. BURDICK (G.GREENE COLLECTION, NOV-67) | | | |
| HIDDEN CRK LK | 1968 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1969 | 6 | 27 | 239 | 08/28/69 | POST/OUTB | POST RELEASE, PERCHED BERGS | PHOTO | A. POST,69R3-201,B&W,DISTANT OBLIQUE | 923.3 | | 3029 |
| HIDDEN CRK LK | 1970 | 8 | 26 | 238 | 08/28/70 | POST/OUTB | POST RELEASE, ICEBERG STRANDLINE | PHOTO | AEROMAP ROLL#70-23APT FL/FR(5-17&4-19) | 925.4 | | 3036 |
| HIDDEN CRK LK | 1971 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1972 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1973 | 10 | 6 | 279 | 10/06/73 | POST/OUTB | HIGHWATER MARK EAST CHANNEL | M.MILES | AKDOT DATED PHOTO | | | |
| HIDDEN CRK LK | 1974 | 9 | 4 | 247 | 09/04/74 | POST/OUTB | POST RELEASE,SMALL LAKE,REFILLING? | PHOTO | USGS,EL-13000',#74V106-110,B&W | | | |
| HIDDEN CRK LK | 1975 | 8 | 16 | 228 | 08/18/75 | POST/OUTB | WASHED OUT KENNICOTT R. BRIDGE APPROACH | M.MILES | AKDOT RECORDS | | | |
| HIDDEN CRK LK | 1976 | 7 | 22 | 203 | 07/22/76 | POST/OUTB | IMM. POST RELEASE, LK MUD MARK, SMALL LK | PHOTO | USGS,#78M1-121,OBLIQUE,1:20179,B&W | | | |
| HIDDEN CRK LK | 1977 | 6 | 6 | 216 | 08/06/77 | POST/OUTB | RELEASED PRIOR AUG 5/6, BRIDGE DAMAGE | G. GREENE | VERBAL COMM. | | | |
| HIDDEN CRK LK | 1978 | 8 | 28 | 240 | 08/28/78 | POST/OUTB | DRAINAGE HOLE VISIBLE | PHOTO | NASA,#FL104B-7957&8,1;60000,CIR | 925.3 | | 3036 |
| HIDDEN CRK LK | 1979 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1980 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1981 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1982 | 7 | 31 | 212 | 07/31/82 | POST/OUTB | PEAK STAGE LINE VISIBLE, POST RELEASE | N.OLMSTED | PHOTOS AND PER COMM. SITE VISITED 7/82 | | | |
| HIDDEN CRK LK | 1983 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1984 | 6 | 31 | 243 | 08/31/84 | POST/OUTB | POST RELEASE, SOME PERCHED ICEBERGS | PHOTO | USGS,84R3, OBLIQUE | 921.7 | | 3024 |
| HIDDEN CRK LK | 1985 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1986 | 9 | 6 | 249 | 09/06/86 | POST/OUTB | DRAIN HOLES,BEACHED BERGS | PHOTO | NPS,12WRST-3-45-29&30,1:12000,CIR | | | |
| HIDDEN CRK LK | 1987 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1988 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1989 | | | | | POST/OUTB | | | | | | |
| HIDDEN CRK LK | 1990 | 6 | 13 | 225 | 08/13/90 | POST/OUTB | SMALL LAKE, POST RELEASE | SLIDE | C. PRELLER & L.MAYO FLIGHT | 916.1 | | 3006 |
| HIDDEN CRK LK | 1991 | 6 | 5 | 217 | 08/05/91 | POST/OUTB | | USGS | DRAFT REPORT STAN JONES TABLE #2 | | | |
| HIDDEN CRK LK | 1992 | 7 | 7 | 188 | 07/07/92 | POST/OUTB | PEAK DISCHARGE AT TRAM | STAGE GAGE | USGS KENNICOTT RIVER STAGE RECORD | | | |
| HIDDEN CRK LK | 1993 | 7 | 6 | 187 | 07/06/93 | POST/OUTB | VISUAL CONFIRMATION, ALOT OF BERGS | SLIDE | GROUND,OBLIQUE,HUMMEL TRIP | | | |
| HIDDEN CRK LK | 1994 | 7 | 30 | 211 | 07/30/94 | POST/OUTB | RELEASE OVER, PRIOR TO 9:00AM | PHOTO | AERIAL OBSERVATION, ROSENKRANS | | | |
| HIDDEN CRK LK | 1995 | 7 | 24 | 205 | 07/24/95 | POST/OUTB | NO WATER,ICE CRACKING AND NOISY 10:00 | PHOTO | ROSENKRANS, OBSERVATION | | | |

# APPENDIX 2

Location and description of survey monuments

## SURVEY DATUMS

A common datum was established throughout the basin. Horizontal control was established using the North American Datum of 1927. All elevation data presented in this report are referenced to U.S. Geological Survey monument "K," elevation stamped 1,414 ft, 1908. This monument is located on the east side of McCarthy. Global position satellite and total station survey techniques were used to establish vertical datum at Hidden Creek Lake, the Kennicott Glacier terminus area, and the Kennicott River. Survey monuments established at Hidden Creek Lake and Kennicott River are described below. Vertical datums used by the Alaska Department of Transportation and Public Facilities (ADOT&PF)(1994), and the University of Alaska (1995) were different from the datum used for this report.

Kennicott and Hidden Creek Lake Survey Monuments

| Monument name | Monument description |
|---|---|
| K | Base. USGS benchmark K, est. 1908, elev. given at 1414 ft (430.99 meters), located in the town of McCarthy, Alaska |
| KENW | Wooden stake located on the right bank West Fork Kennicott River 60 ft southwest from tram concrete platform. Established September 17, 1991. |
| KENE | Wooden stake located on centerline of old rail bed, on right bank approximately 100 ft south from road. Established May 31, 1991. |
| AIR1 | Temporary reference mark used to run GPS survey to Hidden Creek Lake. Temporary due to airport construction. |
| HID1, 2, and 3 | Established at Hidden Creek valley airstrip to determine elevation via GPS. |
| WILLOW | Monument established July 1994. Tablet installed August 28, 1994. Located on small rock outcrop north of Hidden Creek Lake. |
| VALLEY | Tablet installed August 28, 1994. Monument is located on valley floor along north bank of Hidden Creek |
| HIDDEN | Tablet installed August 28, 1994. Monument is located on flat rock in valley bottom. May be difficult to find because of iceberg deposition. |
| ROCK | Wooden stake located on rock glacier on south side of Hidden Creek Lake. Established August 29, 1994. Tablet was not installed because of snowfall on August 29 and 30. |
| BOULDER | Tablet installed on August 30 on top of large boulder near "A" frame west of airstrip. |

Survey data for monuments at Hidden creek Valley were established using GPS techniques and a single known starting point, U.S. Geological Survey monument "K" in McCarthy. Elevation errors of the Hidden Creek Valley monuments are probably plus or minus 3 feet (1 meter), relative to monument "K." Elevation errors of Hidden Creek Valley monuments relative to each other, are plus or minus 1 foot (0.3 meter).

| Monument Name | Latitude (North) | Longitude (West) | Northing (feet) | Easting (feet) | Zone | Elevation (feet) |
|---|---|---|---|---|---|---|
| K | 61 25 57.583 | 142 55 10.549 | 22351104 | 1304520 | 07 | 1414 |
| AIR-1 | 61 26 35.148 | 142 53 41.286 | 22354790 | 1308970 | 07 | 1512 |
| KENW | 6126 03.044 | 142 56 35.065 | 22351780 | 1300429 | 07 | 1359 |
| KENE | 6126 05.407 | 142 55 55.326 | 22351963 | 1302368 | 07 | 1370 |
| HID-1 | 61 33 26.708 | 143 08 53.538 | 22397932 | 1266020 | 07 | 3125 |
| HID-2 | 61 33 27.294 | 143 08 43.862 | 22397976 | 1266491 | 07 | 3117 |
| HID-3 | 61 33 29.326 | 143 08 50.520 | 22398193 | 1266175 | 07 | 3123 |
| VALLEY | 61 33 31.130 | 143 07 03.125 | 22398205 | 1271380 | 07 | 3024 |
| HIDDEN | 31 33 38.190 | 143 06 51.922 | 22398905 | 1271945 | 07 | 3009 |
| WILLOW | 61 33 39.149 | 143 07 10.447 | 22399031 | 1271052 | 07 | 3117 |
| ROCK | 61 33 28.577 | 143 06 33.691 | 22397901 | 1272795 | 07 | 3155 |
| BOULDER | 61 33 29.739 | 143 09 08.023 | 22398262 | 1265329 | 07 | 3175 |

To obtain meters, multiply feet by 3.281.

Marks were painted on bedrock near the WILLOW monument for tape-down references to obtain lake-surface elevation. They are:

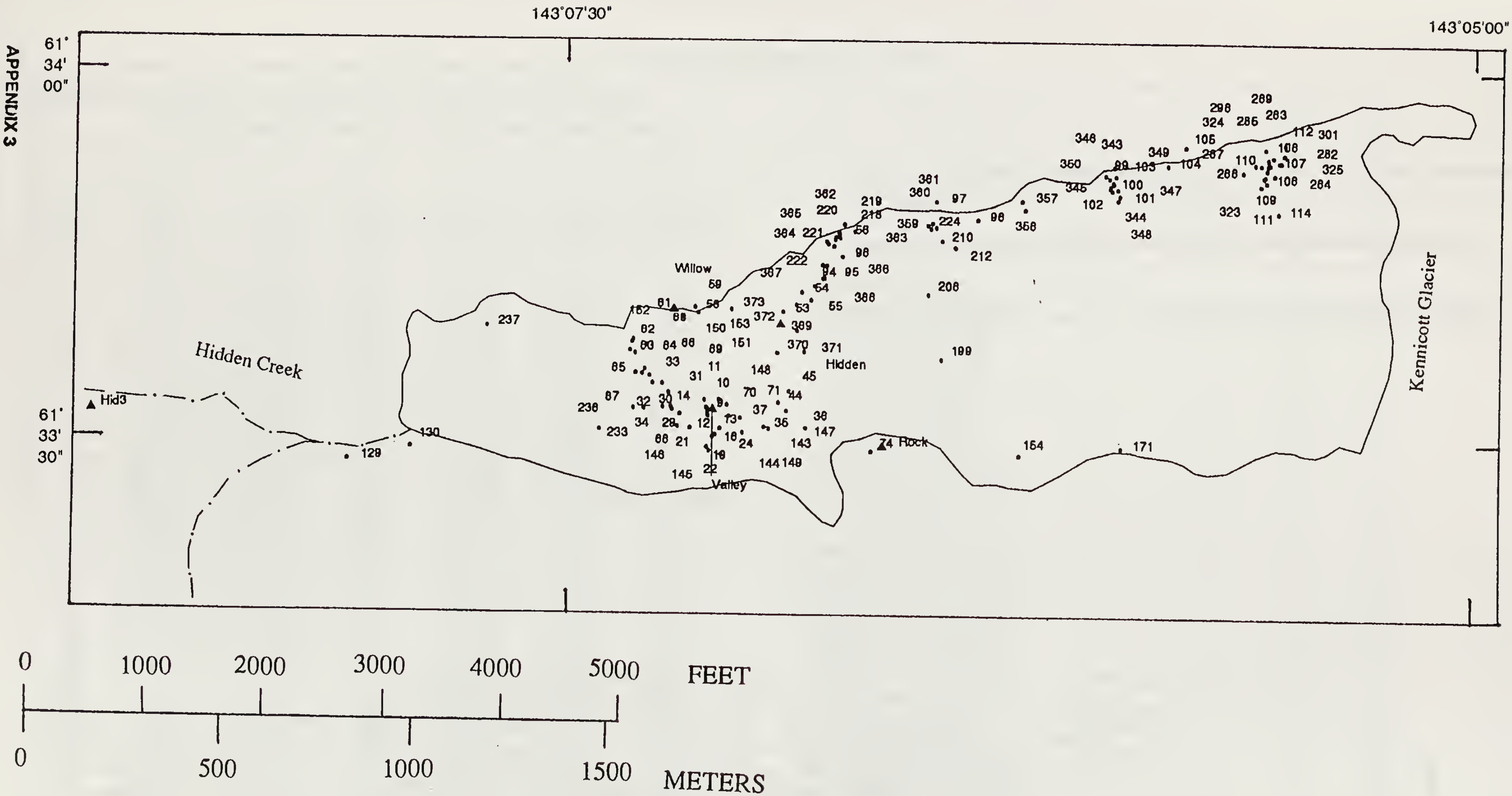
- •Blue cross immediately southwest of WILLOW monument. Elevation: 3031 feet.
- •Blue painted rock below blue cross. Elevation: 3004 feet.

To adjust Alaska Department of Transportation and Public Facilities survey datum of 1994 to USGS datum of 1908, add 3.92 feet.

To adjust University of Alaska Fairbanks (Aeromap, Inc.) survey datum of 1994 to USGS datum of 1908, add approximately 15.5 feet.

# APPENDIX 3

Hidden Creek Lake data survey, 1994 and 1995




Lake surface taken from July 27, 1957 aerial photograph (USGS, scale 1:48,000)

▲ Monument, established 1994; See appendix 2 for coordinates and descriptions

• Survey points, August 1994 and 1995; See Table A3 for coordinates and site descriptions

**Figure A3-1.** Hidden Creek Lake survey monument, lake stage, dropstone deposits, and iceberg data-point locations.

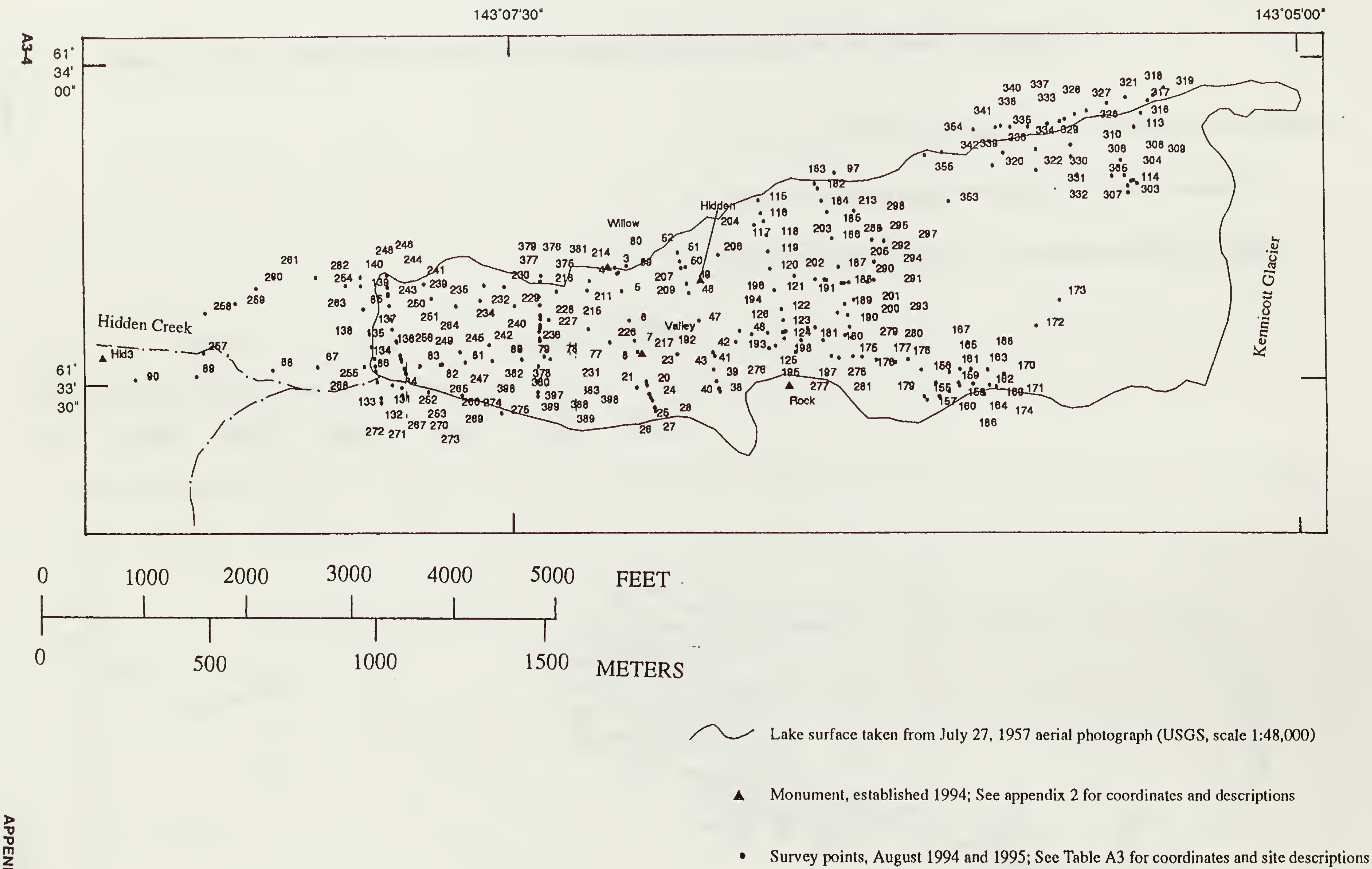



**Figure A3-2.** Hidden Creek Lake survey monument and geomorphic data-point locations.

**Table A3.** Hidden Creek Lake survey data, 1994 and 1995.
(see figures A3-1 and A3-2 for survey point location)

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 1271945 | 22398905 | 3009 | 387670 | 6826853 | 917 | HIdden monument |
| 2 | 1270813 | 22397507 | 3008 | 387325 | 6826427 | 916.8 | Hidden monument -invert |
| 3 | 1271115 | 22399023 | 3053 | 387417 | 6826889 | 930.6 | Geomorphic profile |
| 4 | 1271141 | 22398970 | 3023 | 387425 | 6826873 | 921.5 | Geomorphic profile |
| 5 | 1271184 | 22398800 | 3025 | 387438 | 6826821 | 922.1 | Geomorphic profile |
| 6 | 1271253 | 22398514 | 3024 | 387459 | 6826734 | 921.7 | Geomorphic profile |
| 7 | 1271302 | 22398324 | 3024 | 387474 | 6826676 | 921.7 | Geomorphic profile |
| 8 | 1271335 | 22398222 | 3025 | 387484 | 6826645 | 922 | Geomorphic profile |
| 9 | 1271322 | 22398212 | 3022 | 387480 | 6826642 | 921.2 | Paleo hlgh-water mark |
| 10 | 1271332 | 22398209 | 3021 | 387483 | 6826641 | 920.8 | Paleo high-water mark |
| 11 | 1271305 | 22398275 | 3028 | 387475 | 6826661 | 923 | Top of rock |
| 12 | 1271335 | 22398193 | 3016 | 387484 | 6826636 | 919.3 | Paleo high-water mark |
| 13 | 1271335 | 22398163 | 3010 | 387484 | 6826627 | 917.3 | Lake level, 7-16-94 1245 pm |
| 14 | 1271338 | 22398144 | 3003 | 387485 | 6826621 | 915.4 | Hidden Creek pws, 8-30-94 |
| 15 | 1271345 | 22398091 | 3006 | 387487 | 6826605 | 916.3 | Topographical definition |
| 16 | 1271351 | 22398055 | 3010 | 387489 | 6826594 | 917.3 | Topographical definition |
| 17 | 1271351 | 22398035 | 3012 | 387489 | 6826588 | 918.1 | Topographlcal definition |
| 18 | 1271378 | 22397970 | 3020 | 387497 | 6826568 | 920.4 | Paleo high-water mark |
| 19 | 1271401 | 22397989 | 3017 | 387504 | 6826574 | 919.6 | Debris line |
| 20 | 1271417 | 22397940 | 3020 | 387509 | 6826559 | 920.5 | Geomorphic profile |
| 21 | 1271325 | 22397884 | 3026 | 387481 | 6826542 | 922.2 | Blue rock #2, top of rock |
| 22 | 1271348 | 22397851 | 3020 | 387488 | 6826532 | 920.4 | Paleo debris line, excellent |
| 23 | 1271424 | 22397907 | 3019 | 387511 | 6826549 | 920.2 | Geomorphic profile |
| 24 | 1271447 | 22397825 | 3019 | 387518 | 6826524 | 920 | debris line, 7-27-94, excellent |
| 25 | 1271460 | 22397792 | 3020 | 387522 | 6826514 | 920.3 | Geomorphic profile |
| 26 | 1271473 | 22397763 | 3025 | 387526 | 6826505 | 922 | Debris line, 7-27-94 |
| 27 | 1271499 | 22397694 | 3046 | 387534 | 6826484 | 928.3 | Geomorphic profile |
| 28 | 1271506 | 22397658 | 3058 | 387536 | 6826473 | 932 | Geomorphic profile |
| 29 | 1271191 | 22398042 | 3023 | 387440 | 6826590 | 921.3 | Paleo debris |
| 30 | 1271082 | 22398055 | 3027 | 387407 | 6826594 | 922.5 | Paleo debris |
| 31 | 1271102 | 22398160 | 3017 | 387413 | 6826626 | 919.6 | Debris, 1994, from iceberg |
| 32 | 1271030 | 22398219 | 3016 | 387391 | 6826644 | 919.3 | Debris, 1994, flagged |
| 33 | 1270958 | 22398216 | 3020 | 387369 | 6826643 | 920.4 | Debris line, 7-27-94, excellent |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 34 | 1270800 | 22398206 | 3027 | 387321 | 6826640 | 922.5 | Debris line, 7-27-94, excellent | | | |
| 35 | 1271807 | 22398052 | 2995 | 387628 | 6826593 | 912.9 | Marked, 7-09-94 | | | |
| 36 | 1272152 | 22398045 | 2980 | 387733 | 6826591 | 908.4 | Marked, 6-28-94 | | | |
| 37 | 1271627 | 22398006 | 3001 | 387573 | 6826579 | 914.7 | 6-24-93, air photo | | | |
| 38 | 1272129 | 22397845 | 3022 | 387726 | 6826530 | 921.1 | Geomorphic profile | | | |
| 39 | 1272119 | 22397874 | 3007 | 387723 | 6826539 | 916.5 | Geomorphic profile | | | |
| 40 | 1272093 | 22397943 | 2999 | 387715 | 6826560 | 914.2 | Geomorphic profile, 16 ft. from stream | | | |
| 41 | 1272067 | 22398052 | 2984 | 387707 | 6826593 | 909.5 | Geomorphic profile | | | |
| 42 | 1272077 | 22398180 | 3001 | 387710 | 6826632 | 914.8 | Hidden Creek channel, left bank | | | |
| 43 | 1272057 | 22398216 | 3004 | 387704 | 6826643 | 915.7 | Geomorphic profile | | | |
| 44 | 1271926 | 22398252 | 3010 | 387664 | 6826654 | 917.4 | Lake stage, 7-16-94 | | | |
| 45 | 1272014 | 22398347 | 3007 | 387691 | 6826683 | 916.6 | Ice berg #2, 1986 photo | | | |
| 46 | 1272313 | 22398413 | 3001 | 387782 | 6826703 | 914.7 | Geomorphic profile | | | |
| 47 | 1271926 | 22398511 | 3009 | 387664 | 6826733 | 917 | Geomorphic profile | | | |
| 48 | 1271834 | 22398780 | 3008 | 387636 | 6826815 | 916.8 | Geomorphic profile | | | |
| 49 | 1271811 | 22398872 | 3011 | 387629 | 6826843 | 917.6 | Geomorphic profile | | | |
| 50 | 1271758 | 22399020 | 3013 | 387613 | 6826888 | 918.4 | Geomorphic profile | | | |
| 51 | 1271745 | 22399079 | 3025 | 387609 | 6826906 | 922.1 | Geomorphic profile | | | |
| 52 | 1271722 | 22399164 | 3051 | 387602 | 6826932 | 930 | Geomorphic profile | | | |
| 53 | 1271965 | 22399003 | 3005 | 387676 | 6826883 | 915.8 | Peak stage, 1986 | | | |
| 54 | 1272122 | 22399167 | 3005 | 387724 | 6826933 | 915.8 | Ice berg #1, 1986 photo | | | |
| 55 | 1272195 | 22399102 | 3003 | 387746 | 6826913 | 915.2 | Stage, 7-2-92, from aerial photo | | | |
| 56 | 1272431 | 22399653 | 3060 | 387818 | 6827081 | 932.6 | Tape-down point | | | |
| 57 | 1271945 | 22398905 | 3008 | 387670 | 6826853 | 916.9 | HIDDEN monument (checks O.K.) | | | |
| 58 | 1271256 | 22398993 | 3021 | 387460 | 6826880 | 920.7 | 7-27-94 peak stage | | | |
| 59 | 1271227 | 22399036 | 3031 | 387451 | 6826893 | 923.8 | Blue "X"; down-lake from WILLOW | | | |
| 60 | 1271227 | 22399042 | 3036 | 387451 | 6826895 | 925.3 | Tape-down point #2 | | | |
| 61 | 1271132 | 22398957 | 3024 | 387422 | 6826869 | 921.6 | Ice berg #1, 7-22-76 | | | |
| 62 | 1270712 | 22398767 | 3034 | 387294 | 6826811 | 924.6 | Ice berg #1, 8-26-70 | | | |
| 63 | 1270685 | 22398675 | 3036 | 387286 | 6826783 | 925.3 | Ice berg #1, 8-78 | | | |
| 64 | 1270728 | 22398652 | 3036 | 387299 | 6826776 | 925.2 | Ice berg #2, 9-4-74 | | | |
| 65 | 1270731 | 22398495 | 3036 | 387300 | 6826728 | 925.3 | Ice berg #1, 9-4-74 | | | |
| 66 | 1270787 | 22398488 | 3034 | 387317 | 6826726 | 924.8 | Ice berg #2, 8-78 | | | |
| 67 | 1270849 | 22398472 | 3034 | 387336 | 6826721 | 924.7 | Ice berg #2, 8-20-70 | | | |
| 68 | 1270876 | 22398416 | 3027 | 387344 | 6826704 | 922.6 | Pre-94 debris line, prism at 6.3 ft. | | | |
| 69 | 1271007 | 22398334 | 3023 | 387384 | 6826679 | 921.5 | Peak stage, 7-27-94, prism at 7.7 ft. | | | |
| 70 | 1271430 | 22398278 | 3021 | 387513 | 6826662 | 920.7 | Peak stage, 7-27-94, 10 a.m. | | | |
| 71 | 1271492 | 22398235 | 3021 | 387532 | 6826649 | 920.7 | Peak stage, 7-27-94, 10:15 a.m. | | | |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 72 | 1272795 | 22397901 | 3155 | 387929 | 6826547 | 961.7 | ROCK monument | | | |
| 73 | 1269964 | 22398514 | 3154 | 387066 | 6826734 | 961.4 | ROCK monument (invert shot) | | | |
| 74 | 1272700 | 22397851 | 3040 | 387900 | 6826532 | 926.5 | Top of glacier | | | |
| 75 | 1270777 | 22398734 | 3040 | 387314 | 6826801 | 926.6 | Rock #3 | | | |
| 76 | 1271912 | 22398258 | 3013 | 387660 | 6826656 | 918.3 | Rock | | | |
| 77 | 1270781 | 22398170 | 3036 | 387315 | 6826629 | 925.2 | Longitudinal profile | | | |
| 78 | 1270492 | 22398153 | 3041 | 387227 | 6826624 | 927 | Longitudinal profile | | | |
| 79 | 1270219 | 22398153 | 3046 | 387144 | 6826624 | 928.3 | Longitudinal profile | | | |
| 80 | 1269934 | 22398140 | 3052 | 387057 | 6826620 | 930.2 | Longitudinal profile | | | |
| 81 | 1269675 | 22398127 | 3058 | 386978 | 6826616 | 931.9 | Longitudinal profile | | | |
| 82 | 1266778 | 22398107 | 3061 | 386095 | 6826610 | 933 | Longitudinal profile | | | |
| 83 | 1269232 | 22398094 | 3066 | 386843 | 6826606 | 934.5 | Longitudinal profile | | | |
| 84 | 1268973 | 22397917 | 3071 | 386764 | 6826552 | 935.9 | Lake stage,7-29-57 from air photo | | | |
| 85 | 1268694 | 22398639 | 3072 | 386679 | 6826772 | 936.2 | Lake stage,7-29-57 from air photo | | | |
| 86 | 1268700 | 22398091 | 3072 | 386681 | 6826605 | 936.4 | Longitudinal profile, prism at 7.2 ft. | | | |
| 87 | 1268251 | 22398091 | 3080 | 386544 | 6826605 | 938.8 | Longitudinal profile, prism at 6.6 ft. | | | |
| 88 | 1267814 | 22398065 | 3088 | 386411 | 6826597 | 941.3 | Longitudinal profile, prism at 5.2 ft. | | | |
| 89 | 1267080 | 22398009 | 3103 | 386187 | 6826580 | 945.9 | Longitudinal profile | | | |
| 90 | 1266489 | 22397983 | 3118 | 386007 | 6826572 | 950.3 | Longitudinal profile, end | | | |
| 91 | 1271945 | 22398905 | 3009 | 387670 | 6826853 | 917.1 | HIDDEN monument | | | |
| 92 | 1273648 | 22396897 | 3008 | 388189 | 6826241 | 916.9 | HIDDEN, invert shot | | | |
| 93 | 1273648 | 22396897 | 3008 | 388189 | 6826241 | 916.9 | HIDDEN, invert check shot | | | |
| 94 | 1272224 | 22399216 | 3000 | 387755 | 6826948 | 914.5 | Stage, 7-2-92, aerial photo | | | |
| 95 | 1272293 | 22399282 | 2997 | 387776 | 6826968 | 913.3 | Stage, 6-24-93, aerial photo | | | |
| 96 | 1272457 | 22399462 | 2995 | 387826 | 6827023 | 912.9 | Stage, 7-9-94, from photo | | | |
| 97 | 1273238 | 22399925 | 3099 | 388064 | 6827164 | 944.4 | Tape down point #3 | | | |
| 98 | 1273582 | 22399768 | 3038 | 388169 | 6827116 | 926 | Peak stage, 8-6-75, aerial photo | | | |
| 99 | 1274646 | 22400151 | 3045 | 388493 | 6827233 | 928.2 | Peak stage, 8-6-75, strand line | | | |
| 100 | 1274682 | 22400056 | 3020 | 388504 | 6827204 | 920.6 | Peak stage, 7-27-94 | | | |
| 101 | 1274747 | 22399941 | 2979 | 388524 | 6827169 | 908 | Lake level, 7-29-94 10:30 am | | | |
| 102 | 1274682 | 22400043 | 3019 | 388504 | 6827200 | 920 | Ice berg #3, 9-4-74 photograph | | | |
| 103 | 1274705 | 22400092 | 3025 | 388511 | 6827215 | 921.9 | Stage, 8-6-75, from photograph | | | |
| 104 | 1275161 | 22400233 | 3080 | 388650 | 6827258 | 938.8 | Possible strandline | | | |
| 105 | 1275312 | 22400391 | 3154 | 388696 | 6827306 | 961.3 | Old trail or strandline ? | | | |
| 106 | 1275974 | 22400378 | 3055 | 388898 | 6827302 | 931.1 | Highest elevation for time lapse camera | | | |
| 107 | 1276014 | 22400250 | 3022 | 388910 | 6827263 | 921.2 | Stage, 7-24-94, 12:15 pm | | | |
| 108 | 1275984 | 22400099 | 2988 | 388901 | 6827217 | 910.8 | Stage, 7-4-94, 1730, Walder and Driedger | | | |
| 109 | 1275971 | 22400151 | 3004 | 388897 | 6827233 | 915.6 | Blue painted rock (reference) | | | |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 110 | 1275964 | 22400142 | 2999 | 388895 | 6827230 | 914.1 | Stage, 7-9-94, 5:17 pm | | | |
| 111 | 1275938 | 22400066 | 2976 | 388887 | 6827207 | 906.9 | Stage, 7-29-94, 1028 am,lake draining) | | | |
| 112 | 1276138 | 22400414 | 3084 | 388948 | 6827313 | 939.9 | Moraine, top of stake | | | |
| 113 | 1276119 | 22400358 | 3061 | 388942 | 6827296 | 933 | Geomorphic profile | | | |
| 114 | 1276086 | 22399840 | 2907 | 388932 | 6827138 | 886.1 | Stage, 7-29-94, 5:30 p.m. | | | |
| 115 | 1272500 | 22399656 | 3053 | 387839 | 6827082 | 930.5 | Geomorphic profile | | | |
| 116 | 1272519 | 22399535 | 3007 | 387845 | 6827045 | 916.6 | Geomorphic profile | | | |
| 117 | 1272552 | 22399459 | 2990 | 387855 | 6827022 | 911.4 | Geomorphic profile | | | |
| 118 | 1272579 | 22399325 | 2989 | 387863 | 6826981 | 911 | Geomorphic profile | | | |
| 119 | 1272592 | 22399170 | 2996 | 387867 | 6826934 | 913.2 | Geomorphic profile | | | |
| 120 | 1272608 | 22399010 | 2995 | 387872 | 6826885 | 912.7 | Geomorphic profile | | | |
| 121 | 1272654 | 22398803 | 2993 | 387886 | 6826822 | 912.1 | Geomorphic profile | | | |
| 122 | 1272716 | 22398619 | 2993 | 387905 | 6826766 | 912.3 | Geomorphic profile | | | |
| 123 | 1272733 | 22398511 | 2992 | 387910 | 6826733 | 912 | Geomorphic profile | | | |
| 124 | 1272729 | 22398399 | 2981 | 387909 | 6826699 | 908.5 | Geomorphic profile | | | |
| 125 | 1272743 | 22398340 | 2967 | 387913 | 6826681 | 904.4 | Geomorphic profile | | | |
| 126 | 1272661 | 22398268 | 2951 | 387888 | 6826659 | 899.5 | Geomorphic profile | | | |
| 127 | 1266020 | 22397934 | 3125 | 385864 | 6826557 | 952.4 | HID 1 monument | | | |
| 128 | 1266000 | 22398455 | 3125 | 385858 | 6826716 | 952.4 | Invert shot on HID 1 monument | | | |
| 129 | 1268326 | 22397769 | 3083 | 386567 | 6826507 | 939.6 | Upper limits of lake sediments | | | |
| 130 | 1268855 | 22397881 | 3074 | 386728 | 6826541 | 936.9 | Upper limits of lake sediments | | | |
| 131 | 1268864 | 22397750 | 3086 | 386731 | 6826501 | 940.5 | Geomorphic profile | | | |
| 132 | 1268864 | 22397799 | 3073 | 386731 | 6826516 | 936.5 | Geomorphic profile | | | |
| 133 | 1268825 | 22397950 | 3073 | 386719 | 6826562 | 936.5 | Geomorphic profile | | | |
| 134 | 1268812 | 22398048 | 3069 | 386715 | 6826592 | 935.3 | Geomorphic profile | | | |
| 135 | 1268805 | 22398098 | 3066 | 386713 | 6826607 | 934.4 | Geomorphic profile | | | |
| 136 | 1268799 | 22398166 | 3069 | 386711 | 6826628 | 935.4 | Geomorphic profile | | | |
| 137 | 1268773 | 22398278 | 3069 | 386703 | 6826662 | 935.3 | Geomorphic profile | | | |
| 138 | 1268750 | 22398403 | 3072 | 386696 | 6826700 | 936.3 | Geomorphic profile | | | |
| 139 | 1268668 | 22398862 | 3074 | 386671 | 6826840 | 936.9 | Geomorphic profile | | | |
| 140 | 1268668 | 22398947 | 3097 | 386671 | 6826866 | 944 | Geomorphic profile, prism at 5.8 ft. | | | |
| 141 | 1265331 | 22398262 | 3175 | 385654 | 6826657 | 967.6 | BOULDER monument | | | |
| 142 | 1267020 | 22398124 | 3174 | 386169 | 6826615 | 967.5 | BOULDER monument (invert shot) | | | |
| 143 | 1271847 | 22398042 | 2992 | 387640 | 6826590 | 911.9 | Stage, 7-8-95 | | | |
| 144 | 1271696 | 22397920 | 3003 | 387594 | 6826553 | 915.2 | Debris line, 1995 | | | |
| 145 | 1271440 | 22398042 | 3007 | 387516 | 6826590 | 916.4 | Debris line, 1996 | | | |
| 146 | 1271040 | 22398196 | 3017 | 387394 | 6826637 | 919.6 | Debris line, 1997 | | | |
| 147 | 1271994 | 22398186 | 3005 | 387685 | 6826634 | 916 | Ice berg, 7-23-95 | | | |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 148 | 1271607 | 22398127 | 3002 | 387567 | 6826616 | 914.9 | Ice berg, 7-23-96 | | | |
| 149 | 1271512 | 22398144 | 3003 | 387538 | 6826621 | 915.4 | Debris line, 1995 | | | |
| 150 | 1270830 | 22398724 | 3032 | 387330 | 6826798 | 924.1 | Stage, 7-72, NASA | | | |
| 151 | 1270954 | 22398406 | 3031 | 387368 | 6826701 | 923.7 | Stage, 7-72, NASA | | | |
| 152 | 1270702 | 22398747 | 3034 | 387291 | 6826805 | 924.6 | Ice berg, 8-26-70 | | | |
| 153 | 1270807 | 22398524 | 3036 | 387323 | 6826737 | 925.4 | Ice berg, 8-26-70 | | | |
| 154 | 1273937 | 22397819 | 2999 | 388277 | 6826522 | 913.9 | 8/25/95 | | | |
| 155 | 1274094 | 22397792 | 3056 | 388325 | 6826514 | 931.5 | Topographical definition | | | |
| 156 | 1274065 | 22398042 | 2961 | 388316 | 6826590 | 902.6 | Topographical definition | | | |
| 157 | 1274124 | 22397760 | 3078 | 388334 | 6826504 | 938.2 | Topographical definition | | | |
| 158 | 1274242 | 22397792 | 3083 | 388370 | 6826514 | 939.6 | Topographical definition | | | |
| 159 | 1274206 | 22397920 | 3011 | 388359 | 6826553 | 917.6 | Topographical definition | | | |
| 160 | 1274337 | 22397845 | 3080 | 388399 | 6826530 | 938.7 | Topographical definition | | | |
| 161 | 1274334 | 22398019 | 2978 | 388398 | 6826583 | 907.7 | Topographical definition | | | |
| 162 | 1274422 | 22397920 | 3048 | 388425 | 6826553 | 929 | Topographical definition | | | |
| 163 | 1274432 | 22397894 | 3065 | 388428 | 6826545 | 934.3 | Topographical definition | | | |
| 164 | 1274436 | 22397894 | 3065 | 388429 | 6826545 | 934.24 | Topographical definition | | | |
| 165 | 1274436 | 22398048 | 2975 | 388429 | 6826592 | 906.7 | Topographical definition | | | |
| 166 | 1274564 | 22397911 | 3054 | 388468 | 6826550 | 930.7 | Topographical definition | | | |
| 167 | 1274541 | 22398048 | 2978 | 388461 | 6826592 | 907.7 | Topographical definition | | | |
| 168 | 1274705 | 22398045 | 2979 | 388511 | 6826591 | 907.9 | Topographical definition | | | |
| 169 | 1274718 | 22397901 | 3049 | 388515 | 6826547 | 929.4 | Topographical definition | | | |
| 170 | 1274924 | 22398006 | 2986 | 388578 | 6826579 | 910.1 | Topographical definition | | | |
| 171 | 1274783 | 22397888 | 3050 | 388535 | 6826543 | 929.7 | Exotic block | | | |
| 172 | 1275167 | 22398452 | 2919 | 388652 | 6826715 | 889.7 | Topographical definition | | | |
| 173 | 1275394 | 22398705 | 2924 | 388721 | 6826792 | 891.1 | Topographical definition | | | |
| 174 | 1274672 | 22397815 | 3101 | 388501 | 6826521 | 945.1 | Paleo strand line | | | |
| 175 | 1273409 | 22398166 | 2973 | 388116 | 6826628 | 906.2 | Edge of terrace | | | |
| 176 | 1273494 | 22398160 | 2971 | 388142 | 6826626 | 905.6 | Edge of terrace | | | |
| 177 | 1273635 | 22398137 | 2969 | 388185 | 6826619 | 905 | Edge of terrace | | | |
| 178 | 1273819 | 22398114 | 2961 | 388241 | 6826612 | 902.4 | Edge of terrace | | | |
| 179 | 1273940 | 22398144 | 2958 | 388278 | 6826621 | 901.7 | Edge of terrace | | | |
| 180 | 1273274 | 22398160 | 2974 | 388075 | 6826626 | 906.5 | Edge of terrace | | | |
| 181 | 1273199 | 22398173 | 2973 | 388052 | 6826630 | 906.1 | Edge of terrace | | | |
| 182 | 1273044 | 22399817 | 3097 | 388005 | 6827131 | 944 | Geomorphic profile | | | |
| 183 | 1273071 | 22399774 | 3072 | 388013 | 6827118 | 936.3 | Geomorphic profile | | | |
| 184 | 1273113 | 22399653 | 3007 | 388026 | 6827081 | 916.6 | Geomorphic profile | | | |
| 185 | 1273163 | 22399544 | 2978 | 388041 | 6827048 | 907.5 | Geomorphic profile | | | |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 186 | 1273208 | 22399292 | 2977 | 388055 | 6826971 | 907.4 | Geomorphic profile | | | |
| 187 | 1273268 | 22399029 | 2977 | 388073 | 6826891 | 907.4 | Geomorphic profile | | | |
| 188 | 1273297 | 22398865 | 2964 | 388082 | 6826841 | 903.3 | Geomorphic profile | | | |
| 189 | 1273330 | 22398665 | 2977 | 388092 | 6826780 | 907.4 | Geomorphic profile | | | |
| 190 | 1273356 | 22398560 | 2967 | 388100 | 6826748 | 904.3 | Geomorphic profile | | | |
| 191 | 1273376 | 22398449 | 2947 | 388106 | 6826714 | 898.1 | Geomorphic profile | | | |
| 192 | 1271716 | 22398196 | 3016 | 387600 | 6826637 | 919.1 | Edge of terrace | | | |
| 193 | 1272277 | 22398308 | 2999 | 387771 | 6826671 | 914.2 | Edge of terrace | | | |
| 194 | 1272431 | 223983016 | 2999 | 387818 | 68266692 | 913.9 | Edge of terrace | | | |
| 195 | 1272582 | 22398396 | 2991 | 387864 | 6826698 | 911.7 | Edge of terrace | | | |
| 196 | 1272759 | 22398409 | 2979 | 387918 | 6826702 | 907.9 | Edge of terrace | | | |
| 197 | 1272969 | 22398439 | 2970 | 387982 | 6826711 | 905.2 | Edge of terrace | | | |
| 198 | 1273044 | 22398445 | 2967 | 388005 | 6826713 | 904.2 | Edge of terrace | | | |
| 199 | 1273284 | 22398609 | 2978 | 388078 | 6826763 | 907.6 | Stage, 7-3-95 1200 pm | | | |
| 200 | 1273258 | 22398580 | 2978 | 388070 | 6826754 | 907.8 | Edge of terrace | | | |
| 201 | 1273415 | 22398708 | 2975 | 388118 | 6826793 | 906.6 | Terrace point | | | |
| 202 | 1273327 | 22398869 | 2962 | 388091 | 6826842 | 902.8 | Ravine | | | |
| 203 | 1273133 | 22398901 | 2970 | 388032 | 6826852 | 905.1 | Ravine | | | |
| 204 | 1272460 | 22399420 | 2989 | 387827 | 6827010 | 910.9 | Base of scree slope | | | |
| 205 | 1272844 | 22398944 | 2981 | 387944 | 6826865 | 908.6 | Ravine | | | |
| 206 | 1272113 | 22399144 | 3005 | 387721 | 6826926 | 915.9 | Base of scree slope | | | |
| 207 | 1271798 | 22399023 | 3011 | 387625 | 6826889 | 917.8 | Base of scree slope | | | |
| 208 | 1273172 | 22399151 | 2978 | 388044 | 6826928 | 907.6 | Stage, 7-3-95 1200 pm | | | |
| 209 | 1271401 | 22399082 | 3022 | 387504 | 6826907 | 921.2 | Base of scree slope | | | |
| 210 | 1273284 | 22399594 | 2978 | 388078 | 6827063 | 907.6 | Stage, 7-3-95 1200 pm | | | |
| 211 | 1271151 | 22398977 | 3024 | 387428 | 6826875 | 921.7 | Base of bedrock | | | |
| 212 | 1273395 | 22399538 | 2978 | 388112 | 6827046 | 907.6 | Stage, 7-3-95 1200 pm | | | |
| 213 | 1273418 | 22399554 | 2983 | 388119 | 6827051 | 909.3 | Cairn, 6-30-95 | | | |
| 214 | 1270872 | 22398898 | 3033 | 387343 | 6826851 | 924.5 | Base of scree slope | | | |
| 215 | 1270849 | 22398803 | 3032 | 387336 | 6826822 | 924 | Base of scree slope | | | |
| 216 | 1270557 | 22398800 | 3040 | 387247 | 6826821 | 926.5 | Base of scree slope | | | |
| 217 | 1271381 | 22398206 | 3025 | 387498 | 6826640 | 921.9 | Edge of terrace | | | |
| 218 | 1272556 | 22399672 | 3066 | 387856 | 6827087 | 934.6 | Pre-1938 JP | | | |
| 219 | 1272470 | 22399732 | 3103 | 387830 | 6827105 | 945.9 | Ice berg, 9-12-16 | | | |
| 220 | 1272398 | 22399623 | 3048 | 387808 | 6827072 | 929 | Peak stage, 8-16-74 | | | |
| 221 | 1272326 | 22399390 | 3009 | 387786 | 6827001 | 917 | Ice berg, 7-82 | | | |
| 222 | 1272286 | 22399394 | 3020 | 387774 | 6827002 | 920.6 | Peak stage, 1982 | | | |
| 223 | 1271053 | 22399033 | 3118 | 387398 | 6826892 | 950.2 | WILLOW monument | | | |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 224 | 1273192 | 22399695 | 3010 | 388050 | 6827094 | 917.4 | Peak stage, 8-16-74 | | | |
| 225 | 1271381 | 22398206 | 3025 | 387498 | 6826640 | 921.9 | VALLEY monument | | | |
| 226 | 1271069 | 22398308 | 3028 | 387403 | 6826671 | 923 | Terrace | | | |
| 227 | 1270863 | 22398436 | 3034 | 387340 | 6826710 | 924.6 | Terrace | | | |
| 228 | 1270479 | 22398524 | 3041 | 387223 | 6826737 | 926.9 | Terrace | | | |
| 229 | 1270154 | 22398659 | 3050 | 387124 | 6826778 | 929.5 | Terrace | | | |
| 230 | 1270052 | 22398849 | 3052 | 387093 | 6826836 | 930.2 | Base of scree slope | | | |
| 231 | 1270758 | 22398173 | 3037 | 387308 | 6826630 | 925.7 | Edge of terrace | | | |
| 232 | 1269859 | 22398862 | 3055 | 387034 | 6826840 | 931.2 | Base of scree slope | | | |
| 233 | 1270712 | 22398206 | 3032 | 387294 | 6826640 | 924.1 | Ice berg, 7-72 | | | |
| 234 | 1269822 | 22398718 | 3055 | 387023 | 6826796 | 931 | Terrace | | | |
| 235 | 1269586 | 22398662 | 3058 | 386951 | 6826779 | 932.1 | Terrace | | | |
| 236 | 1270429 | 22398032 | 3041 | 387208 | 6826587 | 927 | Stage, 1974 w.. | | | |
| 237 | 1269488 | 22398878 | 3060 | 386921 | 6826845 | 932.7 | Stage, pre-1938 jp.. | | | |
| 238 | 1270436 | 22398183 | 3042 | 387210 | 6826633 | 927.2 | Edge of terrace | | | |
| 239 | 1269350 | 22398741 | 3062 | 386879 | 6826803 | 933.3 | Edge of terrace | | | |
| 240 | 1270193 | 22398245 | 3048 | 387136 | 6826652 | 928.9 | Edge of terrace | | | |
| 241 | 1269281 | 22398875 | 3065 | 386858 | 6826844 | 934.1 | Base of scree slope | | | |
| 242 | 1269904 | 22398288 | 3052 | 387048 | 6826665 | 930.3 | Edge of terrace | | | |
| 243 | 1268933 | 22398787 | 3071 | 386752 | 6826817 | 936 | Base of scree slope | | | |
| 244 | 1268933 | 22398787 | 3071 | 386752 | 6826817 | 936 | Base of scree slope | | | |
| 245 | 1269629 | 22398226 | 3058 | 386964 | 6826646 | 932.1 | Edge of terrace | | | |
| 246 | 1268923 | 22398960 | 3106 | 386749 | 6826870 | 946.6 | Geomorphic profile | | | |
| 247 | 1269455 | 22398111 | 3061 | 386911 | 6826611 | 932.9 | Edge of terrace | | | |
| 248 | 1268927 | 22398846 | 3078 | 386750 | 6826835 | 938.2 | Geomorphic profile | | | |
| 249 | 1269238 | 22398098 | 3066 | 386845 | 6826607 | 934.4 | Edge of terrace | | | |
| 250 | 1268930 | 22398787 | 3071 | 386751 | 6826817 | 935.9 | Geomorphic profile | | | |
| 251 | 1268930 | 22398767 | 3065 | 386751 | 6826811 | 934.3 | Geomorphic profile | | | |
| 252 | 1269068 | 22397825 | 3068 | 386793 | 6826524 | 935.2 | Geomorphic profile | | | |
| 253 | 1269078 | 22397789 | 3085 | 386796 | 6826513 | 940.3 | Geomorphic profile | | | |
| 254 | 1268946 | 22398668 | 3066 | 386756 | 6826781 | 934.6 | Geomorphic profile | | | |
| 255 | 1269061 | 22397891 | 3070 | 386791 | 6826544 | 935.6 | Geomorphic profile | | | |
| 256 | 1268953 | 22398541 | 3067 | 386758 | 6826742 | 934.7 | Geomorphic profile | | | |
| 257 | 1267148 | 22398232 | 3101 | 386208 | 6826648 | 945.2 | Exotic block | | | |
| 258 | 1267168 | 22398603 | 3105 | 386214 | 6826761 | 946.4 | Base of scree slope | | | |
| 259 | 1267460 | 22398701 | 3100 | 386303 | 6826791 | 944.7 | Base of scree slope | | | |
| 260 | 1267664 | 22398846 | 3092 | 386365 | 6826835 | 942.3 | Base of scree slope | | | |
| 261 | 1267824 | 22398954 | 3087 | 386414 | 6826868 | 940.8 | Base of scree slope | | | |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 262 | 1268238 | 22398947 | 3080 | 386540 | 6826866 | 938.7 | Base of scree slope | | | |
| 263 | 1268523 | 22398865 | 3074 | 386627 | 6826841 | 936.8 | Base of scree slope | | | |
| 264 | 1268969 | 22398445 | 3066 | 386763 | 6826713 | 934.6 | Geomorphic profile | | | |
| 265 | 1269009 | 22398331 | 3066 | 386775 | 6826678 | 934.4 | Geomorphic profile | | | |
| 266 | 1269015 | 22398321 | 3062 | 386777 | 6826675 | 933.1 | Geomorphic profile | | | |
| 267 | 1269048 | 22398199 | 3062 | 386787 | 6826638 | 933.4 | Geomorphic profile | | | |
| 268 | 1269058 | 22398163 | 3061 | 386790 | 6826627 | 932.8 | Geomorphic profile | | | |
| 269 | 1269061 | 22398144 | 3062 | 386791 | 6826621 | 933.2 | Geomorphic profile | | | |
| 270 | 1269084 | 22398075 | 3062 | 386798 | 6826600 | 933.2 | Geomorphic profile | | | |
| 271 | 1269101 | 22398035 | 3063 | 386803 | 6826588 | 933.7 | Geomorphic profile | | | |
| 272 | 1269104 | 22398025 | 3068 | 386804 | 6826585 | 935.2 | Geomorphic profile | | | |
| 273 | 1269320 | 22397851 | 3065 | 386870 | 6826532 | 934.2 | Base of scree slope | | | |
| 274 | 1269645 | 22397819 | 3060 | 386969 | 6826522 | 932.6 | Base of scree slope | | | |
| 275 | 1270023 | 22397645 | 3067 | 387084 | 6826469 | 934.7 | Base of scree slope | | | |
| 276 | 1272601 | 22398248 | 2956 | 387870 | 6826653 | 900.9 | Hidden Creek, left edge of water | | | |
| 277 | 1272857 | 22398216 | 2942 | 387948 | 6826643 | 896.7 | Hidden Creek, left edge of water | | | |
| 278 | 1273120 | 22398324 | 2926 | 388028 | 6826676 | 891.9 | Hidden Creek, left edge of water | | | |
| 279 | 1273333 | 22398367 | 2917 | 388093 | 6826689 | 889.1 | Hidden Creek, left edge of water | | | |
| 280 | 1273395 | 22398347 | 2914 | 388112 | 6826683 | 888.2 | Hidden Creek, left edge of water | | | |
| 281 | 1272910 | 22398327 | 2959 | 387964 | 6826677 | 902 | Topographic definition | | | |
| 282 | 1276132 | 22400332 | 3051 | 388946 | 6827288 | 929.8 | Ice berg, 8-24-64 | | | |
| 283 | 1276106 | 22400270 | 3031 | 388938 | 6827269 | 923.7 | Peak stage, 1982 | | | |
| 284 | 1276092 | 22400270 | 3029 | 388934 | 6827269 | 923.3 | Ice berg, 8-27-69 | | | |
| 285 | 1275997 | 22400296 | 3033 | 388905 | 6827277 | 924.5 | Pre-1938 stage, "Icy" Lake | | | |
| 286 | 1275889 | 22400247 | 3025 | 388872 | 6827262 | 922 | Peak stage, 8-16-74 | | | |
| 287 | 1275791 | 22400184 | 3013 | 388842 | 6827243 | 918.3 | Ice berg, 8-31-84 | | | |
| 288 | 1273044 | 22398901 | 2974 | 388005 | 6826852 | 906.5 | Gully | | | |
| 289 | 1276001 | 22400263 | 3025 | 388906 | 6827267 | 922 | Peak stage, 8-16-74 | | | |
| 290 | 1273159 | 22398898 | 2968 | 388040 | 6826851 | 904.7 | Gully | | | |
| 291 | 1273369 | 22398875 | 2958 | 388104 | 6826844 | 901.5 | Gully | | | |
| 292 | 1273550 | 22398882 | 2951 | 388159 | 6826846 | 899.4 | Gully | | | |
| 293 | 1273612 | 22398898 | 2961 | 388178 | 6826851 | 902.4 | Topographic definition | | | |
| 294 | 1273615 | 22399069 | 2971 | 388179 | 6826903 | 905.6 | Topographic definition | | | |
| 295 | 1273596 | 22399282 | 2956 | 388173 | 6826968 | 900.8 | Gully | | | |
| 296 | 1273684 | 22399380 | 2971 | 388200 | 6826998 | 905.6 | Topographic definition | | | |
| 297 | 1273710 | 22399266 | 2948 | 388208 | 6826963 | 898.4 | Gully | | | |
| 298 | 1275938 | 22400243 | 3023 | 388887 | 6827261 | 921.3 | Ice berg, 8-26-70 | | | |
| 299 | 1273770 | 22399643 | 2984 | 388226 | 6827078 | 909.6 | Topographical definition | | | |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks |
|---|---|---|---|---|---|---|---|
| 300 | 1274045 | 22399745 | 2982 | 388310 | 6827109 | 908.8 | Topographical definition |
| 301 | 1276050 | 22400165 | 3007 | 388921 | 6827237 | 916.6 | Peak stage, 7-23-95 |
| 302 | 1274294 | 22399774 | 2995 | 388386 | 6827118 | 912.7 | Topographical definition |
| 303 | 1276060 | 22399725 | 2862 | 388924 | 6827103 | 872.2 | Terminal moraine |
| 304 | 1276145 | 22399814 | 2888 | 388950 | 6827130 | 880.1 | Terminal moraine |
| 305 | 1276056 | 22399794 | 2884 | 388923 | 6827124 | 879.1 | Terminal moraine |
| 306 | 1276112 | 22399846 | 2905 | 388940 | 6827140 | 885.3 | Terminal moraine |
| 307 | 1276024 | 22399892 | 2929 | 388913 | 6827154 | 892.7 | Terminal moraine |
| 308 | 1275902 | 22399886 | 2910 | 388876 | 6827152 | 886.8 | Terminal moraine |
| 309 | 1275964 | 22399981 | 2917 | 388895 | 6827181 | 889.1 | Terminal moraine |
| 310 | 1275984 | 22400040 | 2971 | 388901 | 6827199 | 905.4 | Terminal moraine |
| 311 | 1276024 | 22400129 | 2999 | 388913 | 6827226 | 914.2 | Terminal moraine |
| 312 | 1276060 | 22400197 | 3018 | 388924 | 6827247 | 919.7 | Terminal moraine |
| 313 | 1276096 | 22400276 | 3031 | 388935 | 6827271 | 923.8 | Terminal moraine |
| 314 | 1276112 | 22400322 | 3050 | 388940 | 6827285 | 929.6 | Terminal moraine |
| 315 | 1276165 | 22400407 | 3084 | 388956 | 6827311 | 940 | Terminal moraine |
| 316 | 1276181 | 22400489 | 3124 | 388961 | 6827336 | 952.2 | Terminal moraine |
| 317 | 1276250 | 22400614 | 3157 | 388982 | 6827374 | 962.2 | Terminal moraine |
| 318 | 1276302 | 22400670 | 3172 | 388998 | 6827391 | 966.9 | Terminal moraine |
| 319 | 1276404 | 22400739 | 3182 | 389029 | 6827412 | 969.8 | Terminal moraine |
| 320 | 1274757 | 22399987 | 2991 | 388527 | 6827183 | 911.6 | Topographical definition |
| 321 | 1276033 | 22400647 | 3148 | 388916 | 6827384 | 959.6 | Trail |
| 322 | 1275170 | 22399945 | 2954 | 388653 | 6827170 | 900.3 | Topographical definition |
| 323 | 1276040 | 22400312 | 3037 | 388918 | 6827282 | 925.5 | Peak stage, 7-22-76 |
| 324 | 1275994 | 22400240 | 3018 | 388904 | 6827260 | 919.8 | Peak stage, 8-6-75 |
| 325 | 1275987 | 22400204 | 3008 | 388902 | 6827249 | 916.8 | Ice berg, 9-7-74 |
| 326 | 1275853 | 22400588 | 3154 | 388861 | 6827366 | 961.3 | Trail |
| 327 | 1275656 | 22400516 | 3156 | 388801 | 6827344 | 962 | Trail |
| 328 | 1275545 | 22400480 | 3154 | 388767 | 6827333 | 961.2 | Trail |
| 329 | 1275449 | 22400430 | 3153 | 388738 | 6827318 | 961 | Trail |
| 330 | 1275505 | 22400184 | 3033 | 388755 | 6827243 | 924.3 | Topographical definition |
| 331 | 1275508 | 22400073 | 2984 | 388756 | 6827209 | 909.6 | Topographical definition |
| 332 | 1275564 | 22399899 | 2894 | 388773 | 6827156 | 882.2 | Topographical definition |
| 333 | 1275449 | 22400430 | 3153 | 388738 | 6827318 | 960.9 | Trail |
| 334 | 1275400 | 22400411 | 3153 | 388723 | 6827312 | 961 | Trail |
| 335 | 1275285 | 22400388 | 3154 | 388688 | 6827305 | 961.2 | Trail |
| 336 | 1275170 | 22400142 | 3039 | 388653 | 6827230 | 926.1 | Topographical definition |
| 337 | 1275095 | 22400358 | 3154 | 388630 | 6827296 | 961.2 | Trail |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks |
|---|---|---|---|---|---|---|---|
| 338 | 1274924 | 22400358 | 3152 | 388578 | 6827296 | 960.8 | Trail |
| 339 | 1274856 | 22400112 | 3031 | 388557 | 6827221 | 923.8 | Topographical definition |
| 340 | 1274833 | 22400368 | 3150 | 388550 | 6827299 | 960 | Trail |
| 341 | 1274783 | 22400355 | 3152 | 388535 | 6827295 | 960.8 | Trail |
| 342 | 1274573 | 22400329 | 3126 | 388471 | 6827287 | 952.8 | Trail |
| 343 | 1274672 | 22400125 | 3036 | 388501 | 6827225 | 925.4 | Ice berg, 8-26-70 |
| 344 | 1274760 | 22399978 | 2988 | 388528 | 6827180 | 910.6 | Lake stage, 6-24-93 |
| 345 | 1274698 | 22400024 | 3009 | 388509 | 6827194 | 917.1 | Ice berg, 8-31-84 |
| 346 | 1274705 | 22400083 | 3021 | 388511 | 6827212 | 920.8 | Ice berg, 8-27-69 |
| 347 | 1274711 | 22400079 | 3019 | 388513 | 6827211 | 920.2 | Peak stage, 8-16-74 |
| 348 | 1274747 | 22400033 | 3002 | 388524 | 6827197 | 915.1 | Peak stage, 7-23-95 |
| 349 | 1274728 | 22400145 | 3044 | 388518 | 6827231 | 927.8 | Wash line |
| 350 | 1274714 | 22400224 | 3080 | 388514 | 6827255 | 938.6 | Wash line |
| 351 | 1274462 | 22399896 | 3020 | 388437 | 6827155 | 920.3 | Topographical definition |
| 352 | 1274268 | 22399850 | 3025 | 388378 | 6827141 | 922 | Topographical definition |
| 353 | 1274331 | 22399646 | 2937 | 388397 | 6827079 | 895.1 | Base of scree slope |
| 354 | 1274268 | 22400119 | 3138 | 388378 | 6827223 | 956.5 | Trail |
| 355 | 1274104 | 22400092 | 3128 | 388328 | 6827215 | 953.5 | Trail |
| 356 | 1274091 | 22400129 | 3148 | 388324 | 6827226 | 959.6 | Wash line |
| 357 | 1273950 | 22399928 | 3051 | 388281 | 6827165 | 929.8 | Ice berg, 7-10-51 |
| 358 | 1273973 | 22399856 | 3026 | 388288 | 6827143 | 922.3 | Lake stage, 7-10-51 |
| 359 | 1273238 | 22399705 | 3011 | 388064 | 6827097 | 917.6 | Peak stage, 7-23-95 |
| 360 | 1273205 | 22399741 | 3026 | 388054 | 6827108 | 922.3 | Ice berg, 7-10-51 |
| 361 | 1273166 | 22399725 | 3024 | 388042 | 6827103 | 921.7 | Ice berg, 8-31-84 |
| 362 | 1272395 | 22399607 | 3041 | 387807 | 6827067 | 926.8 | Peak stage, 8-16-74 |
| 363 | 1272431 | 22399659 | 3066 | 387818 | 6827083 | 934.6 | Pre-1938 lake stage, |
| 364 | 1272434 | 22399617 | 3042 | 387819 | 6827070 | 927.1 | Ice berg, 8-24-64 |
| 365 | 1272323 | 22399587 | 3045 | 387785 | 6827061 | 928.1 | Peak stage, 8-6-75 |
| 366 | 1272385 | 22399551 | 3021 | 387804 | 6827050 | 920.8 | Ice berg, 8-26-70 |
| 367 | 1272339 | 22399567 | 3035 | 387790 | 6827055 | 925.1 | Lake stage, 7-72 NASA |
| 368 | 1272306 | 22399282 | 2995 | 387780 | 6826968 | 912.7 | Peak stage, 6-24-93 |
| 369 | 1272073 | 22399062 | 3006 | 387709 | 6826901 | 916.1 | Ice berg, 8-13-90 |
| 370 | 1272080 | 22398842 | 3004 | 387711 | 6826834 | 915.7 | Ice berg, 8-13-91 |
| 371 | 1272139 | 22398668 | 3003 | 387729 | 6826781 | 915.2 | Ice berg, 8-13-92 |
| 372 | 1271916 | 22398659 | 3007 | 387661 | 6826778 | 916.6 | Peak stage, 7-23-95 |
| 373 | 1271532 | 22399020 | 3017 | 387544 | 6826888 | 919.5 | Topographical definition |
| 374 | 1271319 | 22399131 | 3047 | 387479 | 6826922 | 928.6 | Pre-1938 stage |
| 375 | 1270403 | 22398954 | 3097 | 387200 | 6826868 | 943.9 | Geomorphic profile |

| Survey point | Easting (feet) | Northing (feet) | Elevation (feet) | Easting (meters) | Northing (meters) | Elevation (meters) | Remarks | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 376 | 1270400 | 22398898 | 3079 | 387199 | 6826851 | 938.5 | Geomorphic profile | | | |
| 377 | 1270390 | 22398750 | 3042 | 387196 | 6826806 | 927.1 | Geomorphic profile | | | |
| 378 | 1270397 | 22398668 | 3044 | 387198 | 6826781 | 927.9 | Geomorphic profile | | | |
| 379 | 1270400 | 22398570 | 3043 | 387199 | 6826751 | 927.5 | Geomorphic profile | | | |
| 380 | 1270400 | 22398534 | 3035 | 387199 | 6826740 | 925 | Geomorphic profile | | | |
| 381 | 1270397 | 22398478 | 3035 | 387198 | 6826723 | 925.1 | Geomorphic profile | | | |
| 382 | 1270397 | 22398452 | 3036 | 387198 | 6826715 | 925.4 | Geomorphic profile | | | |
| 383 | 1270387 | 22398413 | 3035 | 387195 | 6826703 | 924.9 | Geomorphic profile | | | |
| 384 | 1270387 | 22398406 | 3037 | 387195 | 6826701 | 925.6 | Geomorphic profile | | | |
| 385 | 1270387 | 22398390 | 3037 | 387195 | 6826696 | 925.5 | Geomorphic profile | | | |
| 386 | 1270393 | 22398363 | 3033 | 387197 | 6826688 | 924.5 | Geomorphic profile | | | |
| 387 | 1270393 | 22398360 | 3029 | 387197 | 6826687 | 923.2 | Geomorphic profile | | | |
| 388 | 1270393 | 22398347 | 3029 | 387197 | 6826683 | 923.2 | Geomorphic profile | | | |
| 389 | 1270397 | 22398331 | 3031 | 387198 | 6826678 | 923.71 | Geomorphic profile | | | |
| 390 | 1270400 | 22398311 | 3036 | 387199 | 6826672 | 925.2 | Geomorphic profile | | | |
| 391 | 1270387 | 22398262 | 3036 | 387195 | 6826657 | 925.2 | Geomorphic profile | | | |
| 392 | 1270380 | 22398232 | 3036 | 387193 | 6826648 | 925.4 | Geomorphic profile | | | |
| 393 | 1270380 | 22398229 | 3038 | 387193 | 6826647 | 926 | Geomorphic profile | | | |
| 394 | 1270377 | 22398216 | 3038 | 387192 | 6826643 | 925.9 | Geomorphic profile | | | |
| 395 | 1270377 | 22398203 | 3043 | 387192 | 6826639 | 927.6 | Geomorphic profile | | | |
| 396 | 1270377 | 22398088 | 3044 | 387192 | 6826604 | 927.7 | Geomorphic profile | | | |
| 397 | 1270374 | 22397950 | 3042 | 387191 | 6826562 | 927.3 | Geomorphic profile | | | |
| 398 | 1270374 | 22397845 | 3042 | 387191 | 6826530 | 927.1 | Geomorphic profile | | | |
| 399 | 1270374 | 22397806 | 3041 | 387191 | 6826518 | 926.9 | Geomorphic profile | | | |
| 400 | 1270374 | 22397806 | 3041 | 387191 | 6826518 | 926.9 | Geomorphic profile | | | |

# APPENDIX 4

Summary of historical data and references for outburst lakes in the Kennicott basin

# KENNICOTT BASIN OUTBURST LAKES: ALL DATA

| SITE | YEAR | MONTH | DAY | DATE | STATUS | NOTES | SOURCE | S_NOTES |
|---|---|---|---|---|---|---|---|---|
| 4TH JULY LAKE | 48 | 6 | 16 | 06/16/48 | FULL | ICE MARGIN LAKE | PHOTO | TRIMET#301RT-72PL-C-8M164-72RS-16JUNE48-ACR |
| 4TH JULY LAKE | 57 | 7 | 29 | | FULL | NO BERGS | PHOTO | USGS,M230-7813&4,1:40000,B&W |
| 4TH JULY LAKE | 57 | 7 | 29 | | FULL | NO DISCHARGE, LARGE DEPRESSION NEAR LAKE | PHOTO | USGS,M230-7847&8,1:40000,B&W |
| 4TH JULY LAKE | 64 | 8 | 24 | | FULL | STAGE AT LEVEL PREBREECH TO THE WEST | PHOTO | POST,K642-77,B7W,OBLIQUE |
| 4TH JULY LAKE | 70 | 8 | 26 | 08/26/70 | FILLING | BREECHED, DRAINS WESTWARD | PHOTO | AEROMAP ROLL#70-23APT FL/FR(3-11) |
| 4TH JULY LAKE | 72 | 7 | 21 | 07/21/72 | FILLING | PRIOR W.SIDE BREECH, V FULL | PHOTO | NASA/JCS,M#209,FL#24-78,COLOR |
| 4TH JULY LAKE | 78 | 8 | 0 | | FULL | | PHOTO | NASA,ENLARGEMENT,FL105#7525,1:32500,B&W |
| 4TH JULY LAKE | 90 | 8 | 22 | | FILLING | LAKE DRAINS PRIOR TO FILLING? | PHOTO | NPS,R1-90(#7884-86)1:48000,COLOR |
| 4TH JULY LAKE | 93 | 7 | 15 | | FILLING | | SLIDE | ROSENKRANS |
| 4TH JULY LAKE | 94 | 3 | 31 | | LOW STAGE | ICE, BREECH ON WEST SIDE, UNCONNECTED | OBSERVATION | ROSENKRANS, OVERFLIGHT |
| 4TH JULY LAKE | 94 | 5 | 13 | 05/13/94 | FILLING | TWO SMALL LAKES PERCHED ON ICE NEARBY | OBSERVATION | FLIGHT NOTES AND PHOTO |
| 4TH JULY LAKE | 94 | 6 | 5 | 06/05/94 | STATIC | BREECHED, DRAINS TO THE WEST | PHOTO | OBSERVATION, ROSENKRANS |
| BONANZA LAKE 1 | 57 | 7 | 29 | | EMPTY | | PHOTO | USGS,M230-7847&8,1:40000,B&W |
| BONANZA LAKE 1 | 57 | 7 | 29 | | EMPTY | DRAIN HOLE VISIBLE, LAKE PART OF II? | PHOTO | USGS,M230-7904&5,1:40000,B&W |
| BONANZA LAKE 1 | 66 | 7 | 20 | 07/20/66 | EMPTY | H2O DRAIN POINT | PHOTO | AEROMAP ROLL#66-16,FL/FR(9-3) |
| BONANZA LAKE 1 | 70 | 8 | 26 | 08/26/70 | EMPTY | FORMING, POST RELEASE | PHOTO | AEROMAP ROLL#70-23APT FL/FR(3-10) |
| BONANZA LAKE 1 | 72 | 7 | 21 | 07/21/72 | EMPTY | DRAINED | PHOTO | NASA/JCS,M#209,FL#19-218,COLOR |
| BONANZA LAKE 1 | 74 | 8 | | | EMPTY | | SLIDE | VC#825-27 |
| BONANZA LAKE 1 | 74 | 9 | 1 | 09/01/74 | EMPTY | NO H2O OBSERVED | PHOTO | USGS, 74V3-110, B&W, OBLIQUE |
| BONANZA LAKE 1 | 75 | 5 | | | FILLING | | SLIDE | VC,V9#2264-3 |
| BONANZA LAKE 1 | 76 | 6 | 11 | 06/11/76 | FORMING? | SMALL DEPRESSION? RECEIVES H2O | PHOTO | AEROMAP FL#76-7(2-2&3-3) |
| BONANZA LAKE 1 | 76 | 7 | | | EMPTY | | SLIDE | VC,VOL9#4004-34 |
| BONANZA LAKE 1 | 78 | 8 | 0 | | EMPTY | | PHOTO | NASA,ENLARGEMENT,FL105#7525,1:32500,B&W |
| BONANZA LAKE 1 | 78 | 8 | 25 | | EMPTY | | PHOTO | NASA,ENLARGEMENT,FL105B#7087,1:19000,CIR |
| BONANZA LAKE 1 | 83 | 8 | 19 | 08/19/83 | EMPTY | DRAIN HOLE AND CHANNEL | PHOTO | 83-CO3257,FL#14X,FR,#7 |
| BONANZA LAKE 1 | 85 | 9 | 12 | | EMPTY | | PHOTO | MCCARTHY RD,#14-7,1:12000,COLOR |
| BONANZA LAKE 1 | 86 | 6 | 29 | | EMPTY | | PHOTO | NPS,R#5&6(193-195),1;16000,CIR |
| BONANZA LAKE 1 | 86 | 9 | 6 | | EMPTY | | PHOTO | NPS-12WRST-3-42-56&7,1:12000,CIR |
| BONANZA LAKE 1 | 88 | 6 | 28 | | EMPTY | PERCHED LK @ S END, PRERELEASE EL 1930'? | PHOTO | NPS,R#1-88(1215&6),1:500',B&W |
| BONANZA LAKE 1 | 89 | 8 | 10 | | EMPTY | | PHOTO | NPS,BONANZA PK#1&2,1:40000,COLOR |
| BONANZA LAKE 1 | 89 | 8 | 10 | | EMPTY | | MAP | NPS KENNECOTT CLAIMS, 1:2400, 10'C |
| BONANZA LAKE 1 | 90 | 8 | 22 | | EMPTY | BONANZA CRK DRAINS INTO HOLE | PHOTO | NPS,1-90(#7858-60,73-76)1:48000,COLOR |
| BONANZA LAKE 1 | 92 | 7 | 0 | | EMPTY | | SLIDE | ROSENKRANS |
| BONANZA LAKE 1 | 92 | 7 | 2 | | EMPTY | | SLIDE | ROSENKRANS |
| BONANZA LAKE 1 | 93 | 7 | 15 | | EMPTY | | SLIDES | ROSENKRANS |
| BONANZA LAKE 1 | 94 | 3 | 31 | | EMPTY | NO ICE | OBSERVATION | ROSENKRANS, OVERFLIGHT |
| BONANZA LAKE 1 | 94 | 5 | 13 | 05/13/94 | FILLING | MOD. STAGE, MUDDY WATER | PHOTO | ROSENKRANS, NOTES |
| BONANZA LAKE 1 | 94 | 5 | 24 | 05/24/94 | DRAINING | STAGE DECREASING @18:30 | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 1 | 94 | 5 | 26 | 05/26/94 | DRAINING | STAGE DROPPING | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 1 | 94 | 5 | 30 | 05/30/94 | EMPTY | OBSERVED 6/1 | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 1 | 94 | 6 | 4 | 06/04/94 | EMPTY | DRAINING H20 | PHOTO | OBSERVATION, ROSENKRANS |
| BONANZA LAKE 1 | 94 | 7 | 15 | 07/15/94 | EMPTY | NO ACTIVITY WHILE ERIE IS DRAINING | PHOTO | OBSERVATION,ROSENKRANS |
| BONANZA LAKE 1 | 95 | 4 | 3 | | EMPTY | | OBSERVATION | AERIAL OBSERVATION, ROSENKRANS |
| BONANZA LAKE 2 | 57 | 7 | 29 | | EMPTY | CONNECTED WITH BONANZA I? | PHOTO | USGS,M230-7904&5,1:40000,B&W |
| BONANZA LAKE 2 | 57 | 7 | 29 | | EMPTY | | PHOTO | USGS,M230-7847&8,1:40000,B&W |
| BONANZA LAKE 2 | 66 | 7 | 20 | 07/20/66 | EMPTY | H2O DRAIN POINT | PHOTO | AEROMAP ROLL#66-16,FL/FR(9-3) |
| BONANZA LAKE 2 | 70 | 8 | 26 | 08/26/70 | EMPTY | FORMING, POST RELEASE | PHOTO | AEROMAP ROLL#70-23APT FL/FR(3-10) |
| BONANZA LAKE 2 | 72 | 7 | 21 | 07/21/72 | EMPTY | DRAINED | PHOTO | NASA/JCS,M#209,FL#19-218,COLOR |
| BONANZA LAKE 2 | 74 | 8 | | | EMPTY | | SLIDE | VC #825-27 |
| BONANZA LAKE 2 | 74 | 9 | 1 | 09/01/74 | EMPTY | NO H2O OBSERVED | PHOTO | USGS, 74V3-110, B&W, OBLIQUE |
| BONANZA LAKE 2 | 76 | 6 | 11 | 06/11/76 | FORMING? | RECEIVES H2O, CHANNEL DRAIN HOLE | PHOTO | AERMAP FL#76-7(2-2&3-3) |

## KENNICOTT BASIN OUTBURST LAKES: ALL DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| BONANZA LAKE 2 | 78 | 8 | 0 | | EMPTY | | PHOTO | NASA,ENLARGEMENT,FL105#7525,1:32500,B&W |
| BONANZA LAKE 2 | 78 | 8 | 25 | | EMPTY | | PHOTO | NASA,ENLARGEMENT,FL105B#7087,1;19000,CIR |
| BONANZA LAKE 2 | 85 | 9 | 12 | 09/12/85 | EMPTY | | PHOTO | MCCARTHY RD, AKDOT #14-9, 1:12000, CIR |
| BONANZA LAKE 2 | 86 | 6 | 29 | | FILLING | SMALL LAKE WATER LEVEL 1930' | PHOTO | NPS,R#5&6(193-195),1;16000,CIR |
| BONANZA LAKE 2 | 86 | 9 | 6 | | EMPTY | | PHOTO | NPS-12WRST3-42-56&7,1:12000,CIR |
| BONANZA LAKE 2 | 88 | 6 | 28 | | FILLING | WATER LEVEL 1920' | PHOTO | NPS,R#1-88(1215&6),1:500',B&W |
| BONANZA LAKE 2 | 89 | 8 | 10 | | EMPTY | | MAP | NPS KENNECOTT CLAIMS,1:2400, 10'C |
| BONANZA LAKE 2 | 89 | 8 | 10 | | EMPTY | | PHOTO | NPS,BOANAZA PK#1&2,1:40000,COLOR |
| BONANZA LAKE 2 | 90 | 8 | 22 | | EMPTY | | PHOTO | NPS,R1-90(#7858-60,73-76),1:48000,COLOR |
| BONANZA LAKE 2 | 92 | 7 | 0 | | EMPTY | | SLIDE | ROSENKRANS |
| BONANZA LAKE 2 | 92 | 7 | 2 | | EMPTY | | SLIDE | ROSENKRANS |
| BONANZA LAKE 2 | 93 | 7 | 15 | | EMPTY | | SLIDES (2) | ROSENKRANS |
| BONANZA LAKE 2 | 94 | 3 | 31 | | EMPTY | NO ICE | OBSERVATION | ROSENKRANS, OVERFLIGHT |
| BONANZA LAKE 2 | 94 | 5 | 13 | 05/13/94 | EMPTY | | PHOTO | FLIGHT NOTES , ROSENKRANS |
| BONANZA LAKE 2 | 94 | 5 | 20 | 05/20/94 | DRAINING | STAGE DECREASING @10:00-12:00 | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 2 | 94 | 5 | 21 | 05/21/94 | DRAINING | STAGE DECREASING @19:00 | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 2 | 94 | 5 | 24 | 05/24/94 | DRAINING | STAGE DECREASING @18:30 | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 2 | 94 | 5 | 25 | 05/25/94 | STATIC | STAGE UNCHANGED @17:00 | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 2 | 94 | 5 | 26 | 05/26/94 | DRAINING | STAGE DROPPING | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 2 | 94 | 5 | 28 | 05/28/94 | DRAINING | STAGE DROPPING | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 2 | 94 | 5 | 30 | 05/30/94 | EMPTY | OBSERVED 6/1 | NOTES | OBSERVATION, M. MCDONALD |
| BONANZA LAKE 2 | 94 | 6 | 4 | 06/04/94 | EMPTY | DRAINING CREEK | PHOTO | OBSERVATION - ROSENKRANS |
| BONANZA LAKE 2 | 94 | 7 | 15 | 07/15/94 | EMPTY | NO ACTIVITY WHILE ERIE IS DRAINING | PHOTO | OBSERVATION, ROSENKRANS |
| BONANZA LAKE 2 | 95 | 4 | 3 | | EMPTY | | OBSERVATION | AERIAL OBSERVATION, ROSENKRANS |
| BONANZA LAKE ? | 22 | | | | ACTIVE | TUNNEL DRIVEN, CONNECT LAKES TO DRAIN | BATEMAN | GSA BULL V33,P535 |
| DONOHO CRK LAKE | 48 | 6 | 16 | 06/16/48 | FILLING | VERY FULL (?) | PHOTO | TRIMET#300RT-72PL-C-8M164-72RS-16JUNE48-ACR |
| DONOHO CRK LAKE | 57 | 7 | 29 | | EMPTY | SMALL, POSSIBLE ICE IN BOTTOM? | PHOTO | USGS,M230-7848&9,1:40000,B&W |
| DONOHO CRK LAKE | 64 | 8 | 24 | | EMPTY | APPEARS EMPTY | PHOTO | POST-K642-77,B&W, OBLIQUE |
| DONOHO CRK LAKE | 69 | 8 | 27 | 08/27/69 | EMPTY? | NO H2O OBSERVED | PHOTO | USGS, 69LI-252, B&W, OBLIQUE |
| DONOHO CRK LAKE | 70 | 8 | 26 | 08/26/70 | EMPTY | 1970 STAGE LINE VISIBLE | PHOTO | AEROMAP ROLL#70-23APT FL/FR(4-14&16) |
| DONOHO CRK LAKE | 72 | 7 | 21 | 07/21/72 | EMPTY | DRAINED | PHOTO | NASA/JCS,M#209,FL#19-217&218,COLOR |
| DONOHO CRK LAKE | 74 | 9 | 1 | 09/01/74 | FILLING | LATEST DATE KNOWN WITH H20 | PHOTO | USGS, 74V3-113 B&W VERTICAL |
| DONOHO CRK LAKE | 75 | 10 | 9 | 10/09/75 | EMPTY | | PHOTO | USGS 75MS #170 OBLIQUE |
| DONOHO CRK LAKE | 76 | 6 | 11 | 06/11/76 | FILLING | RECEIVING H2O | PHOTO | AERMAP FL#76-7(2-4) |
| DONOHO CRK LAKE | 78 | 8 | 0 | | EMPTY | | PHOTO | NASA,FL105#7526,1;60000,B&W |
| DONOHO CRK LAKE | 78 | 8 | 25 | | EMPTY | | PHOTO | NASA,ENLARGEMENT,FL105B#7087,1:19000,CIR |
| DONOHO CRK LAKE | 86 | 9 | 6 | | EMPTY? | SHADOW, NO STEREO | PHOTO | NPS-12WRST-3-43-39,1:12000,CIR |
| DONOHO CRK LAKE | 89 | 8 | 10 | | EMPTY | | PHOTO | NPS,BONANZA PK#1&2,1:40000,COLOR |
| DONOHO CRK LAKE | 90 | 8 | 22 | 08/22/90 | EMPTY | | PHOTO | NPS,R#1-90, COLOR, FRAME #7873 |
| DONOHO CRK LAKE | 94 | 1 | 2 | | EMPTY | | SLIDES (2) | ROSENKRANS |
| DONOHO CRK LAKE | 94 | 3 | 31 | | LOW STAGE | ICE COVERED | OBSERVATION | DSR, OVERFLIGHT |
| DONOHO CRK LAKE | 94 | 5 | 13 | 05/13/94 | FILLING | HIGH STAGE, MUDDY WATER | PHOTO | FLIGHT NOTES , ROSENKRANS |
| DONOHO CRK LAKE | 94 | 5 | 23 | 05/23/94 | FILLING | 08:30, FILLING, 50% FULL | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 94 | 5 | 26 | 05/26/94 | EMPTY | 12:00 HAD EMPTIED, NOW REFILLING | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 94 | 6 | 5 | 06/05/94 | FILLING | UNFROZEN, HIGH STAGE, ACTIVE CREEK | PHOTO | OBSERVATION, ROSENKRANS |
| DONOHO CRK LAKE | 94 | 6 | 7 | 06/07/94 | FILLING | 09:45 REFILLING SINCE 5/26 ALMOST FULL | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 94 | 6 | 9 | 06/09/94 | EMPTY | 08:45,STRANDLINE BELOW 1ST STRANLINE | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 94 | 6 | 12 | 06/12/94 | EMPTY | 09:00, NO CHANGE | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 94 | 6 | 16 | 06/16/94 | FILLING | 09:00, SMALL POND | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 94 | 6 | 18 | 06/18/94 | DRAINING | 11:00, SMALL POND REMAINS? | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 94 | 6 | 28 | 06/28/94 | EMPTY | AERIAL OBSERVATION, NO H20 | SLIDE | D. ROSENKRANS |
| DONOHO CRK LAKE | 94 | 7 | 15 | 07/15/94 | EMPTY | NO ACTIVITY WHILE ERIE IS DRAINING | PHOTO | OBSERVATION, ROSENKRANS |

## KENNICOTT BASIN OUTBURST LAKES: ALL DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DONOHO CRK LAKE | 94 | 7 | 26 | 07/26/94 | EMPTY | 19:30, 16 OBSERVATIONS SINCE 6/27 | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 94 | 7 | 29 | 07/29/94 | OUTBURST | OUTBURST EVENT 10:43AM, STAGE DOWN 5'? | PHOTO | AERIAL OBSERVATION, ROSENKRANS |
| DONOHO CRK LAKE | 94 | 7 | 30 | 07/30/94 | EMPTY | 9:18AM AERIAL OBSERVATION | PHOTO | ROSENKRANS |
| DONOHO CRK LAKE | 94 | 8 | 2 | 08/02/94 | EMPTY | 09:00, NEW STRANDLINE | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 94 | 8 | 24 | | EMPTY | RECEIVING H20 | OBSERVATION | AERIAL OBSERVATION, ROSENKRANS |
| DONOHO CRK LAKE | 94 | 10 | 13 | 10/13/94 | EMPTY | 12:30, 6 OBSERVATIONS SINCE 8/2 | REPORT | ELCONIN, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 95 | 4 | 3 | | EMPTY | RECEIVING WATER | PHOTO | ROSENKRANS, AERIAL OBSERVATION |
| DONOHO CRK LAKE | 95 | 6 | 6 | | DRAINING | WASH LINE VISIBLE, 5:00PM (-15FT) | AERIAL OBS | NOTES AND PHOTO DSR |
| DONOHO CRK LAKE | 95 | 6 | 7 | | EMPTY | VERY LOW OR EMPTY | M.MCCARTHY | AERIAL OBSERVATION, VER COMM |
| DONOHO CRK LAKE | 95 | 6 | 8 | | EMPTY | AERIAL OBS. 9:00AM | KELLY BAY | VERBAL COMM. |
| DONOHO CRK LAKE | 95 | 6 | 15 | | FILLING | AERIAL OBSERVATION | KELLY BAY | VERBAL COMM. |
| DONOHO CRK LAKE | 95 | 6 | 16 | | EMPTY | AERIAL OBSERVATION | KELLLY BAY | VERBAL COMM. |
| DONOHO CRK LAKE | 95 | 7 | 3 | | EMPTY | AERIAL OBSERVATION | OBSERVATION | OVERFLIGHT, NOTES, ROSENKRANS |
| DONOHO CRK LAKE | 95 | 7 | 22 | | FILLING | STAGE INCREASING, 14:30 | OBSERVATION | VERBAL COMM, LACHAPELLE |
| DONOHO CRK LAKE | 95 | 7 | 23 | | DRAINING | STAGE DROPPING (-15FT) | PHOTO | OBSERVATION AND PHOTO, ROSENKRANS |
| DONOHO CRK LAKE | 95 | 7 | 23 | | FILLING | ICE FRACTURES NOTED, 9:00AM | PHOTO | AERIAL OBSERVATION & PHOTO, ROSENKRANS |
| DONOHO CRK LAKE | 95 | 7 | 24 | | EMPTY | DRAINED 10:00 | OBSERVATION | OBSERVATION, ROSENKRANS |
| DONOHO CRK LAKE | 95 | 8 | 27 | | EMPTY | RECEIVING H20 | OBSERVATION | AERIAL OBSERVATION, NOTES, ROSENKRANS |
| DONOHO CRK LAKE | 95 | 9 | 10 | | FILLING | DRAINED APPROX. THIS DATE | KELLY BAY | AERIAL OBSERVATION |
| DONOHO CRK LAKE | 95 | 9 | 25 | | EMPTY | SEPT. WASHLINE VISIBLE | OBSERVATION | AERIAL OBSERVATION, ROSENKRANS |
| ERIE LAKE | 48 | 6 | 16 | 06/16/48 | FILLING | BELOW PEAK STAGE | PHOTO | TRIMET#243RT-72PL-C-8M164-72RS-16JUNE48-ACR |
| ERIE LAKE | 57 | 7 | 29 | | EMPTY | NARROW AND DEEP,COUPLE BERGS | PHOTO | USGS,#M230-9002&3,1:40000,B&W |
| ERIE LAKE | 57 | 7 | 29 | | FILLING | V SMALL POND,FEW BERGS AT 1/3 LEVEL | PHOTO | USGS,M230-7849&50,1:40000,B&W |
| ERIE LAKE | 70 | 8 | 26 | 08/26/70 | FILLING | 1970 STRANLINE VISIBLE,SMALL POND,BERGS | PHOTO | AEROMAP ROLL#70-23APT FL/FR(5-13) |
| ERIE LAKE | 70 | 8 | 26 | 08/26/70 | FILLING | 1970 STRANLINE VISIBLE,SMALL POND,BERGS | PHOTO | AEROMAP ROLL#70-23APT FL/FR(5-13) |
| ERIE LAKE | 72 | 7 | 21 | 07/21/72 | FILLING | NEAR PEAK STAGE,NO BERGS | PHOTO | NASA/JCS,M#209,FL#19-217,COLOR |
| ERIE LAKE | 76 | 6 | 11 | 06/11/76 | FILLING | RECEIVING H2O | PHOTO | AERMAP FL#76-7(2-8) |
| ERIE LAKE | 78 | 8 | 0 | | EMPTY | BERGS | PHOTO | NASA,FL105#7526,1:60000,B&W |
| ERIE LAKE | 78 | 8 | 28 | | EMPTY | | PHOTO | NASA,#FL104B-7959&60,1:60000,CIR |
| ERIE LAKE | 80 | 7 | 22 | | FILLING | OBSERVED FROM DONOHO PEAK | PHOTO | N. SIMMERMAN SLIDE DATED 7/22/80 |
| ERIE LAKE | 80 | 7 | 24 | | EMPTY | LAKE EMPTY | PHOTO | N. SIMMERMAN SLIDE DATED 7/24/80 |
| ERIE LAKE | 82 | 8 | 1 | 08/01/82 | OUTBURST? | HIGH DISCHARGE, PRE HIDDEN CRK LK EVENT? | NOTES | HECHT, PER. COMM. (DSR INTERPRETATION) |
| ERIE LAKE | 86 | 6 | 29 | | FILLING | WATER LEVEL ABOVE LAT MORAINE KNOTCH | PHOTO | NPS,R#5&6(185&186),1;16000,CIR |
| ERIE LAKE | 86 | 9 | 6 | | EMPTY | ICEBERG LEVEL HIGH | PHOTO | NPS-12WRST-3-41-72&3,1:12000,CIR |
| ERIE LAKE | 86 | 9 | 6 | | EMPTY | DRAIN HOLE,ICEBERG LEVEL HIGH, TERRACES | PHOTO | NPS,12WRST-3-42-46&47,1:12000,CIR |
| ERIE LAKE | 88 | 7 | 17 | 07/17/88 | OUTBURST | STARTED NIGHT OF 7/17 | NOTES | B. HECHT, PER COMM. |
| ERIE LAKE | 89 | 8 | 10 | | EMPTY | BERGS BEYOND LATERAL MORAINE | PHOTO | NPS,BONANZA PK#2&3,1:40000,COLOR |
| ERIE LAKE | 90 | 8 | 22 | | EMPTY | BERGS OUTSIDE L MORAINE FEWER THAN 8/89 | PHOTO | NPS,R1-90(7857,62&3,9)1:48000,COLOR |
| ERIE LAKE | 93 | 6 | 24 | | FILLING | BREACHES LATERAL MORAINE | SLIDE | ROSENKRANS |
| ERIE LAKE | 93 | 7 | 8 | | LEAKING | NEED TO CONFIRM DATA LEAKING/EMPTY | LACHAPELLE | PER COM. SITE VISIT |
| ERIE LAKE | 93 | 7 | 10 | | DRAINING | DRAINED IN 24 HR PERIOD, APPRX. DATE | TRACY ???? | PER.COMM. AT THE SITE DURING RELEASE |
| ERIE LAKE | 93 | 7 | 13 | | OUTBURST | STAGE LEVEL AT TRAM DOCUMENTED | PHOTO | ROSENKRANS,DSR#3-93 GROUND IMAGE |
| ERIE LAKE | 93 | 7 | 13 | | OUTBURST | INCREASE IN STAGE AT TRAM 7/13/&7/14 | STAGE GAGE | USGS KENNICOTT RIVER STAGE RECORD |
| ERIE LAKE | 94 | 3 | 31 | | EMPTY | NO ICE, ONLY BERGS | OBSERVATION | ROSENKRANS OVERFLIGHT |
| ERIE LAKE | 94 | 5 | 13 | 05/13/94 | EMPTY | SNOW, NO MELT?, V.LOW STAGE? | OBSERVATION | FLIGHT NOTES AND PHOTO |
| ERIE LAKE | 94 | 5 | 23 | 05/23/94 | EMPTY | FILLING | REPORT | ELCONIN AERIAL OBSERVATION, 08:30 |
| ERIE LAKE | 94 | 6 | 5 | 06/05/94 | FILLING | UNFROZEN, BELOW 1993 STAGE, ACTIVE CREEK | PHOTO | OBSERVATION, ROSENKRANS |
| ERIE LAKE | 94 | 6 | 18 | 06/19/94 | FILLING | FILLING SINCE 5/23, 10 OBSERVATIONS, 50% FULL | REPORT | ELCONIN AERIAL OBSERVATION, 11:00 |
| ERIE LAKE | 94 | 6 | 28 | 06/28/94 | FILLING | >50% FULL | PHOTO | AERIAL OBSERVATION,ROSENKRANS |
| ERIE LAKE | 94 | 7 | 12 | 07/12/94 | FILLING | FILLING SINCE 5/23, 22 OBSERVATIONS | REPORT | ELCONIN AERIAL OBSERVATION, 07:45 |
| ERIE LAKE | 94 | 7 | 14 | 07/14/94 | DRAINING | FULL, STARTING TO DRAIN, STAGE DOWN 1M | REPORT | ELCONIN AERIAL OBSERVATION, 19:15 |
| ERIE LAKE | 94 | 7 | 14 | 07/14/94 | DRAINING | 1ST REPORTED DECREASE IN STAGAE, PM | NOTES | OBSERVATION, ELCONIN |

## KENNICOTT BASIN OUTBURST LAKES: ALL DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ERIE LAKE | 94 | 7 | 15 | 07/15/94 | DRAINING | STAGE 10'? BELOW PEAK, 12:00 NOON | PHOTO | AERIAL OBSERVATION, ROSENKRANS |
| ERIE LAKE | 94 | 7 | 15 | 07/15/94 | DRAINING | FULL, STAGE DOWN 2M, DRAINING @ N. END | REPORT | ELCONIN,AERIAL OBSERVATION & PHOTO,19:15 |
| ERIE LAKE | 94 | 7 | 16 | 07/16/94 | DRAINING | 10'/PER HR,ONSITE,100'? BELOW PEAK STAGE | NOTES | OBSERVATION, ROSENKRANS, 13:50 |
| ERIE LAKE | 94 | 7 | 16 | 07/16/94 | DRAINING | 50% FULL,STAGE DOWN 20M | REPORT | ELCONIN AERIAL OBSERVATION, 09:15 |
| ERIE LAKE | 94 | 7 | 17 | 07/17/94 | EMPTY | 09:30 | REPORT | ELCONIN, AERIAL OBSERVATION |
| ERIE LAKE | 94 | 7 | 21 | 07/21/94 | EMPTY | 09:00 | REPORT | ELCONIN AERIAL OBSERVATION, |
| ERIE LAKE | 94 | 7 | 24 | 07/24/94 | FILLING | 09:00, VERY LOW STAGE | REPORT | ELCONIN AERIAL OBSERVATION |
| ERIE LAKE | 94 | 7 | 26 | 07/26/94 | FILLING | 19:30 VERY LOW STAGE | REPORT | ELCONIN AERIAL OBSERVATION |
| ERIE LAKE | 94 | 7 | 29 | 07/29/94 | LEAKING | S.POND, 10:46, RECENT STAGE DROP -3M? | PHOTO | AERIAL OBSERVATION, ROSENKRANS |
| ERIE LAKE | 94 | 7 | 29 | 07/29/94 | LEAKING | S.POND, 17:30, STAGE DOWN -5M | PHOTO | AERIAL OBSERVATION, LACHAPELLE |
| ERIE LAKE | 94 | 8 | 2 | 08/02/94 | EMPTY | 19:30 | REPORT | ELCONIN AERIAL OBSERVATION |
| ERIE LAKE | 94 | 8 | 19 | 08/19/94 | EMPTY | 08:45 | REPORT | ELCONIN AERIAL OBSERVATION |
| ERIE LAKE | 94 | 10 | 13 | 10/13/94 | FILLING | 12:30,V.LOW STAGE,FROZEN, DOWN FROM 9/2 | REPORT | ELCONIN, AERIAL OBSERVATION |
| ERIE LAKE | 95 | 4 | 3 | | EMPTY | RECEIVING WATER | PHOTO | ROSENKRANS, AERIAL OBSERVATION |
| ERIE LAKE | 95 | 6 | 30 | | FILLING | AERIAL OBSERVATION | KELLY BAY | VERBAL COMM |
| ERIE LAKE | 95 | 7 | 3 | | FILLING | 50% FULL | OBSERVATION | NOTES, ROSENKRANS |
| ERIE LAKE | 95 | 7 | 8 | | FILLING | NO SIGN OF RELEASE | PHOTO | ROSENKRANS, AERIAL OBSERVATION & NOTES |
| ERIE LAKE | 95 | 7 | 23 | | FILLING | NO EVIDENCE OF DECREASED STAGE 9:00AM | PHOTO | AERIAL OBSERVATION, NOTES, ROSENKRANS |
| ERIE LAKE | 95 | 7 | 23 | | FILLING | 15:00 NO WASHLINE OBSERVED | PHOTO | ROSENKRANS, OBSERVATION |
| ERIE LAKE | 95 | 8 | 2 | | DRAINING | STAGE DROPPING | OBSERVATION | KELLY BAY OVERFLIGHT, PER. COMM |
| ERIE LAKE | 95 | 8 | 27 | | EMPTY | RECEIVING H20 | OBSERVATION | ROSENKRANS, NOTES |
| ERIE LAKE | 95 | 9 | 25 | | FILLING | 1/3 FULL | NOTES | ROSENKRANS, OBSERVATION |
| FIREWEED LK/HOLE | 48 | 6 | 16 | 06/16/48 | EMPTY | FLUVIAL DEPOSITS (?) POSSIBLY ACTIVE PRE 1948 | PHOTO | TRIMET#301RT-72PL-C-8M164-72RS-16JUNE48-ACR |
| FIREWEED LK/HOLE | 57 | 7 | 29 | | EMPTY | WATER ENTERING,EXITING KNOTCH HOLE | PHOTO | USGS,M230-7847&8,1:40000,B7W |
| FIREWEED LK/HOLE | 64 | 8 | 24 | | EMPTY | WATER FLOWING INTO KNOTCH AREA | PHOTO | POST,K642-77,B&W,OBLIQUE |
| FIREWEED LK/HOLE | 70 | 8 | 26 | 08/26/70 | EMPTY | H2O FLOWS IN, NO LAKE | PHOTO | AEROMAP ROLL#70-23APT FL/FR(3-11) |
| FIREWEED LK/HOLE | 72 | 7 | 21 | 07/21/72 | EMPTY | CREEK FLOWS IN | PHOTO | NASA/JCS,M#209,FL#24-78,COLOR |
| FIREWEED LK/HOLE | 78 | 8 | 0 | | EMPTY | CREEK DRAINS INTO KNOTCH HOLE | PHOTO | NASA,ENLARGEMENT,FL105#7525,1:32500,B&W |
| FIREWEED LK/HOLE | 78 | 8 | 25 | | FILLING | HIGHER LEVEL THAN IN SUBSEQUENT YEARS | PHOTO | NASA,FL105B#7089,1:60000,CIR |
| FIREWEED LK/HOLE | 90 | 8 | 22 | | EMPTY | CREEK DRAINS INTO HOLE AT KNOTCH | PHOTO | NPS,R1-90(#7857-58,83-86),1:48000,COLOR |
| FIREWEED LK/HOLE | 94 | 3 | 31 | | EMPTY | STREAM FLOWS IN, DRAINS, NO BLOCKAGE? | OBSERVATION | ROSENKRANS, OVERFLIGHT |
| FIREWEED LK/HOLE | 94 | 5 | 13 | 05/13/94 | EMPTY | WATER FLOWS THROUGH AND OUT KNOTCH | OBSERVATION | FLIGHT NOTES AND PHOTO, ROSENKRANS |
| GATES LAKES | 48 | 6 | 16 | 06/16/48 | FILLING | TWO LAKES OBSERVED | PHOTO | TRIMET#241RT-72PL-C-8M164-72RS-16JUNE48-ACR |
| GATES LAKES | 57 | 7 | 29 | | FILLING | 3 LAKES AT 50% LEVEL? | PHOTO | USGS,M230-7850-2,1:40000,B&W |
| GATES LAKES | 57 | 7 | 29 | | FILLING | 50% FULL?, 3 BODIES OF WATER | PHOTO | USGS,M230-7811-13,1:40000,B&W |
| GATES LAKES | 70 | 8 | 26 | 08/26/70 | FILLING | TWO SMALL PONDS | PHOTO | AEROMAP,ROLL#70-23APT,FL/FR(5-16&17) |
| GATES LAKES | 72 | 7 | 21 | 07/21/72 | FILLING | 2 PONDS CONNECTED, V. FULL | PHOTO | NASA/JCS,M#209,FL#19-215,(#24-81)COLOR |
| GATES LAKES | 75 | 8 | 6 | 08/06/75 | FILLING | | PHOTO | USGS 75M4 #112 OBLIQUE |
| GATES LAKES | 78 | 8 | 0 | | EMPTY? | | PHOTO | NASA,ENLARGEMENT,FL105#7525,1:32500,B&W |
| GATES LAKES | 78 | 8 | 28 | | EMPTY | | PHOTO | NASA,#FL104B-7958&9,1:60000,CIR |
| GATES LAKES | 89 | 8 | 22 | | FILLING | SMALL PONDS,25% FULL/LEVEL? | PHOTO | NPS,R1-90(#7896-72),1:48000,COLOR |
| GATES LAKES | 90 | 8 | 17 | | FILLING | TWO LKS WITH WATER, DATE??? | SLIDES (2) | PRELLER/MAYO FLIGHT |
| GATES LAKES | 94 | 3 | 31 | | EMPTY | NO ICE | OBSERVATION | ROSENKRANS, OVERFLIGHT |
| GATES LAKES | 94 | 5 | 13 | 05/13/94 | FILLING | V.LOW STAGE IN ONE LAKE | OBSERVATION | FLIGHT NOTES AND PHOTO, ROSENKRANS |
| GATES LAKES | 94 | 6 | 9 | 06/09/94 | FILLING | 08:45, 50% FULL | REPORT | ELCONIN, AERIAL OBSERVATION |
| GATES LAKES | 94 | 7 | 4 | 07/04/94 | FILLING | 08:30, UNCHANGED SINCE 6/9, 50% FULL | REPORT | ELCONIN, AERIAL OBSERVATION |
| GATES LAKES | 94 | 7 | 8 | 07/08/94 | STAGE -1M | 09:30, SMALL DROP IN STAGE @ BOTH LAKES | REPORT | ELCONIN, AERIAL OBSERVATION |
| GATES LAKES | 94 | 7 | 24 | 07/24/94 | STAGE -1M | 09:00, UNCHANGED SINCE 7/8 | REPORT | ELCONIN, AERIAL OBSERVATION |
| GATES LAKES | 94 | 7 | 27 | 07/27/94 | STAGE -2M | 07:30, SMALL DROP IN STAGE | REPORT | ELCONIN, AERIAL OBSERVATION |
| GATES LAKES | 94 | 8 | 19 | 08/19/94 | STAGE -2M | 08:45, UNCHANGED SINCE 7/27 | REPORT | ELCONIN, AERIAL OBSERVATION |
| GATES LAKES | 94 | 10 | 13 | 10/13/94 | EMPTY | 12:30, N.LK DOWN, S.LK EMPTY | REPORT | ELCONIN, AERIAL OBSERVATION |
| GATES LAKES | 95 | 4 | 3 | | EMPTY | | PHOTO | DSR AERIAL OBSERVATION |

## KENNICOTT BASIN OUTBURST LAKES: ALL DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GATES LAKES | 95 | 7 | 21 | | FILLING | TWO MUDDY LAKES | OBSERVATION | AERIAL OBSERVATION, ROSENKRANS |
| GATES LAKES | 95 | 7 | 23 | | FILLING | NO SIGN OF DRAINAGE, 9:00AM | PHOTO | AERIAL OBSERVATION, NOTES AND PHOTO |
| GATES LAKES | 95 | 8 | 27 | | EMPTY | DRAINED | OBSERVATION | AERIAL OBSERVATION, ROSENKRANS |
| HIDDEN CRK LAKE | 0 | | | | UNKNOWN | MAPPING ERROR, LAKE DEPICITED AS GLACIER | USGS B#374 | MAP PREPARED BY SCHRADER 1900&1907 |
| HIDDEN CRK LAKE | 7 | | | | ACTIVE | LAKE 0.5X1.5 MILES, FOOT TRAIL N. SIDE | USGS B#374 | ICY LAKE DESCRIBED |
| HIDDEN CRK LAKE | 9 | | | | ACTIVE ? | POTHOLE RELEASED EARLY IN 1909 | USGS B#448 | REFERENCED PAGE 14 |
| HIDDEN CRK LAKE | 11 | 9 | 15 | | OUTBURST | ICY LK BROKE,BRIDGE DAMAGE,POTHOLE ACTIVE | PUBLISHED | COPPER SPIKE, PAGE 128 |
| HIDDEN CRK LAKE | 16 | | | | ACTIVE | FLOOD EVENT DESTROYED RR BRIDGE | USGS B#662 | REFERENCED PAGE 163 |
| HIDDEN CRK LAKE | 16 | 9 | 12 | 09/12/16 | POST/OUTB | STRANDED BERGS, STRANDLINE VISIBLE | USGS B#894 | MOFFIT, PLATE #5A |
| HIDDEN CRK LAKE | 19 | 6 | 25 | EST | FILLING | YEAR/DATE?,STAGE>94,DATE EST @ L.JUNE | PHOTO | PRE-1938 PHOTO,E.HOLLARD-KENNECOTT,KID |
| HIDDEN CRK LAKE | 19 | 7 | 20 | EST | FILLING | YEAR/DATE?,STAGE>94,DATE EST @M/L.JULY | PHOTO | PRE-1938 PHOTO,C.HODGES-KENNECOTT,KID |
| HIDDEN CRK LAKE | 21 | 9 | 16 | 09/16/21 | OUTBURST | POTHOLE GEYSER ACTIVE , 40' HIGH | PUBLISHED | MCCARTHY WEEKLY NEWS, SEP16, 1921 |
| HIDDEN CRK LAKE | 22 | | | | ACTIVE | 0.5X1.5 MILES, DRAINS AUTUMN & SPRING | PUBLISHED | GSA BULL V33,P536, BATEMAN |
| HIDDEN CRK LAKE | 22 | 9 | 2 | 09/02/21 | OUTBURST | POTHOLE BROKE 2 WEEK EARLY | PUBLISHED | MCCARTHY WEEKLY NEWS, SEP. 9, 1922 |
| HIDDEN CRK LAKE | 23 | 8 | 20 | 08/20/23 | OUTBURST | NEW POTHOLE THROUGH MORAINE (8/16-8/23) | PUBLISHED | MCCARTHY WEEKLY NEWS, AUG. 23 1923 |
| HIDDEN CRK LAKE | 25 | 9 | 7 | 09/07/25 | OUTBURST | FLOOD DESTROYED BRIDGE, NUMEROUS SOURCE | PUBLISHED | MCCARTHY WEEKLY NEWS, SEP.12, 1925 |
| HIDDEN CRK LAKE | 26 | 8 | 29 | 08/29/26 | OUTBURST | POTHOLE NOT AS SPECTACULAR AS USUAL | PUBLISHED | MCCARTHY WEEKLY NEWS, SEP. 4, 1926 |
| HIDDEN CRK LAKE | 27 | | | | ACTIVE | USUALLY RELEASED IN AUGUST PRIOR TO 1928 | USGS | BULL #984. MOFFIT COMMENT PLATE 5A,1938 |
| HIDDEN CRK LAKE | 28 | 6 | 16 | 06/16/28 | FILLING | SKETCH FIELD NOTES, WATER LEVEL DEPICTED | NOTES | MOFFIT FIELD NOTES, USGS, BK#639 P105 |
| HIDDEN CRK LAKE | 33 | 8 | 28 | 08/28/33 | OUTBURST? | "POTHOLE BROKE, FOOT KENNICOTT GL." | DATABANK | USWB CLIMATE DATA, YEHLE |
| HIDDEN CRK LAKE | 37 | 8 | 14 | | POST/OUTB? | ICE DAM FRACTURES & POTHOLES DRAINED ? | PHOTO | WASHBURN, #570 |
| HIDDEN CRK LAKE | 45 | 7 | 31 | 07/31/45 | ACTIVE | NO RR BRIDGE, DESTROYED BETWEEN 1938 &1945 | PHOTO | BI-57 WRST COLLECTION,PHOTOGRAPHER UNKN |
| HIDDEN CRK LAKE | 48 | 6 | 16 | 06/16/48 | FILLING | PRERELEASE, A LOT OF SLUSH IN LAKE AT DAM | PHOTO | TRIMET#241RT-72PL-C-8M164-72RS-16JUNE48-ACR |
| HIDDEN CRK LAKE | 51 | 7 | 10 | 07/10/51 | FILLING | PARTLY FULL, 1950 STRANDED BERGS & CREVASS | PHOTO | ALASKA ICE DAMMED LAKES(STONE,1963) FIG#5 |
| HIDDEN CRK LAKE | 57 | 7 | 29 | | FILLING | UPPER END OF LAKE VISIBLE | PHOTO | USGS,M231-8444&5,1:40000,B&W |
| HIDDEN CRK LAKE | 57 | 7 | 29 | 07/29/57 | FILLING | POST, COMMENT ON PHOTO DESCRIPTION | AGIPRJ4.11 | FIELD IGY-RPT,NOTES PHOTO 5X019, 400OEL |
| HIDDEN CRK LAKE | 57 | 7 | 29 | | FILLING | BASE FOR USGS TOPO EL 3028',<40%ICEBERGS | PHOTO | USGS,M230-7813&4,1:40000,B&W |
| HIDDEN CRK LAKE | 57 | 7 | 29 | | FILLING | LAKE LEVEL AT 3028 FOOT ELEVATION | USGS MAP | TOPOGRAPHIC MAP SHOWS LAKE ELEVATION |
| HIDDEN CRK LAKE | 57 | 8 | 1 | | FILLING | APPRX DATE, HIGHEST KNOWN STAGE | PHOTO | A.POST, 4.11 AUG, 1957 |
| HIDDEN CRK LAKE | 57 | 8 | 4 | 08/04/57 | OUTBURST | STRANDLINE,PARTLY DRAINED?,PERCHED BERGS | PHOTO | FIELD IGY-RPT, VIERECK PHOTO #LV-57-B151 |
| HIDDEN CRK LAKE | 57 | 8 | 4 | 08/04/57 | OUTBURST | REFERENCED PHOTO, NOT INSPECTED | IGY PRJ4.2 | FIELD IGY-RPT, MILLETT PHOTO I-126 |
| HIDDEN CRK LAKE | 62 | 8 | 13 | 08/13/62 | LEAKING | STARTED DRAINING, EAST SIDE CARRIED H2O | NOTES | YEHLE, USGS PHOTO AND FIELD NOTES |
| HIDDEN CRK LAKE | 62 | 8 | 14 | 08/14/62 | OUTBURST | RELEASE STARTED 8/13 FINISHED 8/14 | OBSERVATION | YEHLE USGS, NOTES AND PHOTO |
| HIDDEN CRK LAKE | 64 | 8 | 24 | 08/24/64 | POST/OUTB | POST RELEASE, STRANDLINE, | PHOTO | USGS,K642-76, OBLIQUE |
| HIDDEN CRK LAKE | 67 | 9 | 1 | EST | POST/OUTB | STRANDED BERGS, FALL , NO SNOW, EST DATE | SLIDE | G. BURDICK (G.GREENE COLLECTION, NOV-67) |
| HIDDEN CRK LAKE | 68 | 3 | | | OUTBURST? | FLOOD ON CHITINA R OBSERVED | POST/MAYO | USGS HA-#455, REF. (PER COMM MCKECHINE) |
| HIDDEN CRK LAKE | 69 | 8 | 27 | | POST/OUTB | POST RELEASE, PERCHED BERGS | PHOTO | POST,69R3-201,B&W,DISTANT OBLIQUE |
| HIDDEN CRK LAKE | 70 | 8 | 26 | 08/26/70 | POST/OUTB | POST RELEASE, ICEBERG STRANDLINE | PHOTO | AEROMAP ROLL#70-23APT FL/FR(5-17&4-19) |
| HIDDEN CRK LAKE | 72 | 7 | 21 | 07/21/72 | FILLING | STAGE REACHES/EXCEEDS WILLOW RM | PHOTO | NASA/JCS,M#209,FL#24-81,COL(#23-81,CIR) |
| HIDDEN CRK LAKE | 73 | 10 | 6 | | POST/OUTB | 1973 HIGHWATER MARK EAST CHANNEL | M.MILES | AKDOT DATED PHOTO |
| HIDDEN CRK LAKE | 74 | 7 | | | FILLING | VERY HIGH STAGE,PRE-RELEASE | G.GREENE | PHOTO NOT DATED PROCESSED OCTOBER 1974 |
| HIDDEN CRK LAKE | 74 | 8 | 11 | | FILLING | LAKE LEVEL DEPICTED | SLIDE | G.WINLKER, USGS |
| HIDDEN CRK LAKE | 74 | 8 | 16 | | OUTBURST | PHOTOGRAPH DEPICITING STAGE PRE-RELEASE | AK MAG. | SIMMERMAN PHOTO AND ARTICLE, AUG. 1975 |
| HIDDEN CRK LAKE | 74 | 8 | 16 | | OUTBURST | E. CHANNEL BRIDGE DAMAGE | DOCUMENTS | AKDOT, M. MILES |
| HIDDEN CRK LAKE | 74 | 8 | 16 | 08/16/74 | OUTBURST | FLOOD EVENT AND LAKE OBSERVED | PHOTO | G. MULL, SLIDES AND OBSERVATIONS COMM. |
| HIDDEN CRK LAKE | 74 | 9 | 4 | | POST/OUTB | POST RELEASE,SMALL LAKE,REFILLING? | PHOTO | USGS,EL-13000',#74V106-110,B&W |
| HIDDEN CRK LAKE | 75 | 8 | 6 | | OUTBURST | LAKE DRAINING,>50%FULL,STRANDED BERGS | PHOTO | USGS,#75M4-1/2,OBLIQUE,1:20179,B&W |
| HIDDEN CRK LAKE | 75 | 8 | 6 | | OUTBURST | BRIDGE DAMAGE | DOCUMENTS | AKDOT, M. MILES |
| HIDDEN CRK LAKE | 75 | 8 | 16 | | POST/OUTB | WASHED OUT KENNICOTT R. BRIDGE APPROACH | M.MILES | AKDOT RECORDS |
| HIDDEN CRK LAKE | 75 | 10 | 9 | 10/09/75 | POST/OUTB | POST RELEASE, STRANDLINE, STAGE @ 25%? | PHOTO | UDGS 75MS #170&172 OBLIQUE |
| HIDDEN CRK LAKE | 76 | 7 | 22 | | POST/OUTB | IMM. POST RELEASE, LK MUD MARK, SMALL LK | PHOTO | USGS,#76M1-121,OBLIQUE,1:20179,B&W |
| HIDDEN CRK LAKE | 77 | 8 | 6 | | POST/OUTB | RELEASE PRIOR AUG 5/6, BRIDGE DAMAGE | G. GREENE | VERBAL COMM. |

## KENNICOTT BASIN OUTBURST LAKES: ALL DATA

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|---|---|---|---|---|---|---|---|---|
| HIDDEN CRK LAKE | 78 | 8 | 10 | | OUTBURST | LARGE FLOOD | J. MILLER | OBSERVATION, VERBAL COMM. |
| HIDDEN CRK LAKE | 78 | 8 | 28 | | POST/OUTB | ICEBERGS ID STAGE LEVEL RECENT AND OLD | PHOTO | NASA,ENLARGEMENT,FL104#8028,1:32500,B&W |
| HIDDEN CRK LAKE | 78 | 8 | 28 | | POST/OUTB | DRAINAGE HOLE VISIBLE | PHOTO | NASA,#FL104B-7957&8,1;60000,CIR |
| HIDDEN CRK LAKE | 80 | 8 | 7 | | FILLING? | PRE-RELEASE?? FOOT BRIDGE STANDING | OBSERVATION | LACHAPELLE, BRIDGE OBSERVATION, PER COMM |
| HIDDEN CRK LAKE | 81 | 7 | 1 | | FILLING | PRE-RELEASE, FOOT BRIDGE STANDING | OBSERVATION | J. HANNAH, PER. COMM |
| HIDDEN CRK LAKE | 81 | 7 | 19 | | OUTBURST | FLOOD OBSERVED AND BRIDGE COLLAPSED | PHOTO | GREENE,G.PER. COMM AND PHOTO JUL/81 |
| HIDDEN CRK LAKE | 81 | 8 | 7 | 08/07/81 | OUTBURST? | MAJOR FLOOD EVENT ON KENNICOTT RAIN? | NOTES | HECHT PER COMM. |
| HIDDEN CRK LAKE | 81 | 8 | 22 | 08/22/81 | OUTBURST? | SUSPECTED RELEASE DATE, POSSIBLY RAIN ? | NOTES | B. HECHT, PER. COMM. |
| HIDDEN CRK LAKE | 82 | 7 | 6 | | FILLING | APPEARS FULL | PHOTO | OBLIUQE, WASO-MMB 1983 RPT, COLOR |
| HIDDEN CRK LAKE | 82 | 7 | 31 | | POST/OUTB | PEAK STAGE LINE VISIBLE, POST RELEASE | N.OLMSTED | PHOTOS & PER COMM. JULY, DAY UNKNOWN |
| HIDDEN CRK LAKE | 82 | 8 | 1 | 08/01/82 | OUTBURST? | SHARP ANNUAL PEAKS OBSERVED ON KENNICOT | NOTES | HECHT, PER. COMM. |
| HIDDEN CRK LAKE | 82 | 8 | 13 | | OUTBURST? | FLOOD EVENT OBSERVED BETWEEN 8/10 & 8/16 | OBSERVATION | R. ELLIOT,PER. COMM. (VERBAL) |
| HIDDEN CRK LAKE | 82 | 8 | 16 | 08/16/82 | OUTBURST? | SHARP ANNUAL PEAK OBSERVED ON KENNICOTT | NOTES | HECHT, PER. COMM. |
| HIDDEN CRK LAKE | 83 | | | | ACTIVE | PEAK STAGE EXCEEDED 1986 LEVEL | D. FRIEND | D. FRIEND, VERBAL COMM. |
| HIDDEN CRK LAKE | 83 | 8 | 7 | | OUTBURST | FLOOD EVENT OBSERVED, EARLY IN MONTH | OBSERVATION | R. ELLIOT,PER. COMM. (VERBAL) |
| HIDDEN CRK LAKE | 84 | | | | ACTIVE | PEAK STAGE EXCEEDED 1986 LEVEL | D. FRIEND | D. FRIEND, VERBAL COMM. |
| HIDDEN CRK LAKE | 84 | 8 | 1 | | OUTBURST ? | SIDE CHANNEL FLOODED JULY/AUGUST | OBSERVATION | A. SCHNIDER,PER.COMM (VERBAL) |
| HIDDEN CRK LAKE | 84 | 8 | 4 | 08/04/84 | OUTBURST? | LARGE FLOOD EVENT, 1ST WEEK AUGUST | OBSERVATION | G. GREENE, PER COMM. (VERBAL) |
| HIDDEN CRK LAKE | 84 | 8 | 26 | 08/26/84 | OUTBURST? | ANNUAL PEAK DISCHARGE RECORDED WMC | OBSERVATION | WMC DATA, HECHT PER. PER. COMM. (DEFINATE) |
| HIDDEN CRK LAKE | 84 | 8 | 31 | 08/31/84 | POST/OUTB | POST RELEASE, SOME PERCHED ICEBERGS | PHOTO | USGS,84R3, OBLIQUE |
| HIDDEN CRK LAKE | 85 | | | | ACTIVE | PEAK STAGE EXCEEDED 1986 LEVEL | D. FRIEND | D. FRIEND VERBAL COMM. |
| HIDDEN CRK LAKE | 85 | 7 | 27 | 08/27/85 | FILLING | LARGE LAKE | TM IMAGE | LANDSAT PATH 65, ROW 7 |
| HIDDEN CRK LAKE | 85 | 8 | 16 | 08/16/85 | OUTBURST | BIG FLOOD, CLEAR CRK 1M DEEP W/RAINS | NOTES | DAN DOAK, PER COMM (LETTER) |
| HIDDEN CRK LAKE | 86 | 7 | 27 | | FILLING | LAKE LEVEL VISIBLE | PHOTO | ARO-CR HOVIS FIELD SURVEY OF SITE |
| HIDDEN CRK LAKE | 86 | 8 | 2 | | LEAKING | LAKE LEVEL STARTS TO DROP | OBSERVATION | D. FRIEND MS THESIS & CONVERSATION |
| HIDDEN CRK LAKE | 86 | 8 | 6 | | OUTBURST | PEAK STAGE RECORDED ON 1974 AERIAL PHOTO | OBSERVATION | D. FRIEND, MS THESIS & CONVERSATION |
| HIDDEN CRK LAKE | 86 | 9 | 6 | | POST/OUTB | DRAIN HOLES,BEACHED BERGS | PHOTO | NPS,12WRST-3-45-29&30,1:12000,CIR |
| HIDDEN CRK LAKE | 88 | 7 | 18 | 07/18/88 | OUTBURST? | WATER LEVEL @ BASE OF EAST CHANNEL TRAM | NOTES | DAN DOAK, PER. COMM LETTER |
| HIDDEN CRK LAKE | 88 | 7 | 23 | 07/23/88 | OUTBURST | EVENT OBSERVED IN MCCARTHY | NOTES | B. HECHT, PER COMM. (DEFINATE) |
| HIDDEN CRK LAKE | 88 | 7 | 27 | 07/27/88 | OUTBURST | PHOTO OF FLOOD EVENT AT A TRAM | PHOTO | MOSSEN, E&W CHANNELS DATE ??? |
| HIDDEN CRK LAKE | 89 | 7 | 19 | 07/19/89 | OUTBURST? | RIVER VERY HIGH | NOTES | DAN DOAK, PER COMM. (LETTER) |
| HIDDEN CRK LAKE | 90 | 7 | 4 | | OUTBURST | | USGS | DRAFT REPORT,JONES, TABLE #2 |
| HIDDEN CRK LAKE | 90 | 8 | 13 | | POST/OUTB | SMALL LAKE, POST RELEASE | SLIDE | PRELLER/MAYO FLIGHT |
| HIDDEN CRK LAKE | 90 | 8 | 22 | | POST/OUTB | NO WATER,HIDDEN CRK FLOWING INTO HOLE | PHOTO | NPS,R1-90(#7872),1:48000,COLOR |
| HIDDEN CRK LAKE | 91 | 8 | 3 | | OUTBURST | | USGS | DRAFT REPORT STAN JONES TABLE #2 |
| HIDDEN CRK LAKE | 91 | 8 | 5 | | POST/OUTB | | USGS | DRAFT REPORT STAN JONES TABLE #2 |
| HIDDEN CRK LAKE | 92 | 7 | 2 | | FILLING | WATER LEVEL TO ROCK GL, PLOT H2O LEVEL | SLIDE | ROSENKRANS, DATE WITHIN 1 or 2 days |
| HIDDEN CRK LAKE | 92 | 7 | 6 | | OUTBURST | 50% VOLUME,STRANDED BERGS,PEAK 92 STAGE | PHOTO | G. GREEN DATED PHOTO |
| HIDDEN CRK LAKE | 92 | 7 | 7 | | POST/OUTB | PEAK DISCHARGE AT TRAM | STAGE GAGE | USGS KENNICOTT RIVER STAGE RECORD |
| HIDDEN CRK LAKE | 93 | 4 | 7 | | FILLING | LAKE FROZEN | SLIDES (2) | ROSENKRANS |
| HIDDEN CRK LAKE | 93 | 6 | 24 | | FILLING | WATER LEVEL NEAR ROCK GL, PLOT H2O LEVEL | PRINTS (2) | DSR-#3-93 |
| HIDDEN CRK LAKE | 93 | 7 | 5 | | OUTBURST | PEAK DISCHARGE AT TRAM 7/6/93 | STAGE GAGE | USGS STAGE RECORD AT KENNICOTT TRAM |
| HIDDEN CRK LAKE | 93 | 7 | 6 | | POST/OUTB | VISUAL CONFIRMATION, ALOT OF BERGS | SLIDE | GROUND,OBLIQUE,HUMMEL TRIP |
| HIDDEN CRK LAKE | 93 | 9 | 4 | | DRAINING | FLOOD EVENT AT TRAM, HIDDEN LK OR RAIN? | STAGE GAGE | USGS KENNICOTT RIVER STAGE RECORD |
| HIDDEN CRK LAKE | 93 | 9 | 23 | | POST/OUTB | TWO DRAIN HOLES & CLOSEUP SHOTS | SLIDES (8) | ROSENKRANS & PRINT (DSR-#4-10-93) |
| HIDDEN CRK LAKE | 94 | 1 | 2 | 01/02/94 | FILLING | FROZEN LAKE | SLIDES (6) | ROSENKRANS |
| HIDDEN CRK LAKE | 94 | 3 | 31 | 03/31/94 | FILLING | ICE/STAGE HIGHER THAN 1/94? | OBSERVATION | ROSENKRANS, OVERFLIGHT |
| HIDDEN CRK LAKE | 94 | 5 | 13 | 05/13/94 | FILLING | HIGHER STAGE THAN 3/31?, CRK OPEN,SNOW | PHOTO | FLIGHT NOTES , ROSENKRANS |
| HIDDEN CRK LAKE | 94 | 6 | 5 | 06/05/94 | FILLING | FROZEN, BELOW 1993 STAGE, ACTIVE CREEK | PHOTO | OBSERVATION, ROSENKRANS |
| HIDDEN CRK LAKE | 94 | 6 | 28 | 06/28/94 | FILLING | UNFROZEN, STAGE MARKED, ACTIVE CREEK | PHOTO | OBSERVATION, ROSENKRANS |
| HIDDEN CRK LAKE | 94 | 7 | 15 | 07/15/94 | FILLING | AERIAL INSPECTION | PHOTO | OBSERVATION, ROSENKRANS |
| HIDDEN CRK LAKE | 94 | 7 | 16 | 07/16/94 | FILLING | 09:15, -2M WASHLINE ON GLACIER | REPORT | ELCONIN, AERIAL OBSERVATION |

## KENNICOTT BASIN OUTBURST LAKES: ALL DATA

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|---|---|---|---|---|---|---|---|---|
| HIDDEN CRK LAKE | 94 | 7 | 16 | 07/16/94 | FILLING | STAGE MARKED | PHOTO | OBSERVATION, ROSENKRANS |
| HIDDEN CRK LAKE | 94 | 7 | 27 | 07/27/94 | LEAKING | STAGE @-1M?, ICE WASHLINE, RATE 1"/DAY? | PHOTO | OBSERVATION, ROSENKRANS |
| HIDDEN CRK LAKE | 94 | 7 | 28 | 07/28/94 | LEAKING | PM-LAST LIGHT,S. DROP IN ICE DAM EL. ? | PHOTO | USGS TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 94 | 7 | 28 | 07/28/94 | LEAKING | AM-1ST LIGHT, S.ICE BLOCKS BEACHED | PHOTO | USGS TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 94 | 7 | 29 | 07/29/94 | OUTBURST | OUTBURST EVENT 17:30, STAGE DOWN 70'? | PHOTO | AERIAL OBSERVATION, LACHAPELLE |
| HIDDEN CRK LAKE | 94 | 7 | 29 | 07/29/94 | OUTBURST | OUTBURST EVENT 10:00 AM STAGE DOWN 35'? | PHOTO | AERIAL OBSERVATION, DSR |
| HIDDEN CRK LAKE | 94 | 7 | 29 | 07/29/94 | OUTBURST | AM-1ST LIGHT, ICE DAM EL DROPPING | PHOTO | USGS TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 94 | 7 | 30 | 07/30/94 | POST/OUTB | RELEASE OVER, PRIOR TO 9:00AM | PHOTO | AERIAL OBSERVATION, DSR |
| HIDDEN CRK LAKE | 94 | 8 | 2 | 08/02/94 | REFILLING | S. POND STAGE INCREASING UNTIL 8/5 | PHOTO | USGS TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 94 | 8 | 2 | 08/02/94 | REFILLING | SMALL LAKE AT ICE DAM | PHOTO | AERIAL OBSERVATION DSR |
| HIDDEN CRK LAKE | 94 | 8 | 5 | 08/05/94 | DRAINING | S. POND STAGE STARTS TO DECREASE | PHOTO | USGS TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 94 | 8 | 6 | 08/06/94 | DRAINING | S. POND STAGE DECREASES BELOW VIEW | PHOTO | USGS TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 94 | 8 | 8 | 08/08/94 | POST/OUTB | 09:45 | REPORT | ELCONIN, AERIAL OBSERVATION |
| HIDDEN CRK LAKE | 94 | 8 | 19 | 08/19/94 | POST/OUTB | 08:45, UNCHANGED SINCE 8/8 | REPORT | ELCONIN, AERIAL OBSERVATION |
| HIDDEN CRK LAKE | 94 | 8 | 31 | 08/31/94 | REFILLING | SMALL LAKE OBSERVED DURING SURVEY | PHOTO | FIELD SURVEY, ROSENKRANS |
| HIDDEN CRK LAKE | 94 | 9 | 2 | 09/02/94 | POST/OUTB | LAKE DRAINED SOMETIME SINCE 8/31 | PHOTO | AERIAL OBSERVATION, DSR |
| HIDDEN CRK LAKE | 94 | 10 | 13 | 10/13/94 | REFILLING | 12:30, TWO SMALL PONDS @ GLACIER FACE | REPORT | ELCONIN, AERIAL OBSERVATION |
| HIDDEN CRK LAKE | 95 | 1 | 1 | 01/01/95 | FILLING | STAGE BELOW BURIED ICE | PHOTO | ROSENKRANS, AERIAL OBSERVATION |
| HIDDEN CRK LAKE | 95 | 4 | 3 | 03/04/95 | FILLING | SAME AS 1/1/95?? | PHOTO | ROSENKRANS, AERIAL OBSERVATION |
| HIDDEN CRK LAKE | 95 | 6 | 6 | 06/06/05 | FILLING | SNOW MELTED, LOWER THAN 1994 | PHOTO | ROSENKRANS, AERIAL OBSERVATION |
| HIDDEN CRK LAKE | 95 | 7 | 3 | 07/03/95 | FILLING | WATER LEVEL LOWER THAN 1994 | PHOTO | ROSENKRANS- STAGE MARKED |
| HIDDEN CRK LAKE | 95 | 7 | 8 | 07/08/95 | FILLING | WATER LEVEL LOWER THAN 1994 | PHOTO | ROSENKRANS, NOTES & AERIAL OBSERVATION |
| HIDDEN CRK LAKE | 95 | 7 | 20 | 07/20/95 | FILLING | LAKE STAGE INCREASING, TIME LAPSE CAMERA | PHOTO | ROSENKRANS - TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 95 | 7 | 21 | 07/21/95 | LEAKING | LAKE STAGE BEGINS TO DROP (MINOR), MID DAY | PHOTO | ROSENKRANS - TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 95 | 7 | 21 | 07/21/95 | LEAKING | PENDING RELEASE UNDETECTED 14:00, DSR | AERIAL OBS | ROSENKRANS DISTANT OBSERVATION |
| HIDDEN CRK LAKE | 95 | 7 | 21 | 07/21/95 | LEAKING | LAKE STAGE STATIONARY IN AM | PHOTO | ROSENKRANS - TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 95 | 7 | 21 | 07/21/95 | LEAKING | PENDING RELEASE UNDETECTED KELLY BAY, 21:0 | KELLY BAY | VERBAL COMM. TOURIST FLIGHT |
| HIDDEN CRK LAKE | 95 | 7 | 21 | 07/21/95 | OUTBURST | (17:00) CHANGE IN KENNICOTT R. STAGE | HYDROGRAPH | USGS STAGE RECORD, LACHAPELLE INTERPRET |
| HIDDEN CRK LAKE | 95 | 7 | 21 | 07/21/95 | OUTBURST | LAKE STAGE DOWN 2-5 FEET (EST.) AT DUSK | PHOTO | ROSENKRANS - TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 95 | 7 | 22 | 07/22/95 | OUTBURST | LAKE STAGE DOWN 5-10 (EST.) FEET DAWN | PHOTO | ROSENKRANS - TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 95 | 7 | 22 | 07/22/95 | OUTBURST | LAKE STAGE DOWN 5-10'@ 14:00 ( DOWN 10-30 FE | M.MCCARTHY | AERIAL OBSERVATION, LACHAPELLE CONFIRMS |
| HIDDEN CRK LAKE | 95 | 7 | 22 | 07/22/95 | OUTBURST | ICE DAM BEGINS (?) TO DROP | PHOTO | ROSENKRANS - TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 95 | 7 | 23 | 07/23/95 | OUTBURST | WATER @ LEVEL OF TERMINAL MORAINE 9:00 | PHOTO | ROSENKRANS AERIAL OBSERVATION & NOTES |
| HIDDEN CRK LAKE | 95 | 7 | 23 | 07/23/95 | POST/OUTB | ICE DAM STOP DROPPING, NOON-MID DAY | PHOTO | ROSENKRANS - TIME LAPSE CAMERA |
| HIDDEN CRK LAKE | 95 | 7 | 23 | 07/23/95 | POST/OUTB | NO WATER 15:00 | PHOTO | OBSERVATION , ROSENKRANS |
| HIDDEN CRK LAKE | 95 | 7 | 24 | 07/24/95 | POST/OUTB | NO WATER,ICE CRACKING AND NOISY 10:00 | PHOTO | OBSERVATION, ROSENKRANS |
| HIDDEN CRK LAKE | 95 | 8 | 27 | 08/27/95 | REFILLING | RECEIVING H20 | NOTES | AERIAL OBSERVATION, ROSENKRANS |
| HIDDEN CRK LAKE | 95 | 9 | 25 | 09/25/95 | REFILLING | 1/3 FULL LEVEL @ BURIED ICE | PHOTO | AERIAL OBSERVATION , ROSENKRANS |
| JUMBO LAKE | 24 | 5 | 25 | 05/25/24 | EMPTY | "KENNICOTT LK" BROKE, OVERFLOWED 5/20/24 | DATABANK | USWB CLIMATE DATA, YEHLE |
| JUMBO LAKE | 48 | 6 | 16 | 06/16/48 | EMPTY | POST RELEASE | PHOTO | TRIMET#298RT-72PL-C-8M164-72RS-16JUNE48-ACR |
| JUMBO LAKE | 57 | 7 | 29 | | EMPTY | | PHOTO | USGS,M230-7847-9,1:40000,B&W |
| JUMBO LAKE | 57 | 7 | 29 | | EMPTY | LONG AND NARROW, NO BERGS NOTED | PHOTO | USGS,#M230-7904&5,1:40000,B&W, |
| JUMBO LAKE | 64 | 8 | 24 | 08/24/64 | EMPTY | | PHOTO | USGS,K642-76A, OBLIQUE |
| JUMBO LAKE | 64 | 8 | 24 | | EMPTY | APPEARS EMPTY | PHOTO | POST,K642-77,B&W,OBLIQUE |
| JUMBO LAKE | 66 | 7 | 20 | 07/20/66 | EMPTY | H2O DRAIN POINTS @ JUMBO CRK & ROOT GL | PHOTO | AEROMAP ROLL#66-16,FL/FR(9-5) |
| JUMBO LAKE | 70 | 8 | 26 | 08/26/70 | EMPTY | POST RELEASE | PHOTO | AEROMAP ROLL#70-23APT FL/FR(3-10) |
| JUMBO LAKE | 72 | 7 | 21 | 07/21/72 | EMPTY | DRAINED | PHOTO | NASA/JCS,M#209,FL#19-218,COLOR |
| JUMBO LAKE | 74 | 9 | 1 | 10/01/74 | EMPTY | NO H2O OBSERVED | PHOTO | USGS, 74V3-110, B&W, OBLIQUE |
| JUMBO LAKE | 76 | 6 | 11 | 06/11/76 | EMPTY | RECEIVING H2O, CHANNEL DRAIN HOLE | PHOTO | AERMAP FL#76-7(2-4) |
| JUMBO LAKE | 78 | 8 | 0 | | EMPTY | | PHOTO | NASA,ENLARGEMENT,FL105#7525,1:32500,B&W |
| JUMBO LAKE | 78 | 8 | 25 | | EMPTY | | PHOTO | NASA,ENLARGEMENT,FL105B#7087,1:19000,CIR |
| JUMBO LAKE | 83 | 8 | 19 | 08/19/83 | EMPTY | DRAIN HOLE AND CHANNEL, JUMBO CRK ENTERS | PHOTO | 83-CO3257,FL#14X,FR,#7 |

## KENNICOTT BASIN OUTBURST LAKES: ALL DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| JUMBO LAKE | 85 | 9 | 12 | 09/12/85 | EMPTY | | PHOTO | MCCARTHY RD, AKDOT#14-9, 1:12000, CIR |
| JUMBO LAKE | 86 | 6 | 29 | | FILLING | SMALL LAKE BETWEEN JUMBO & AMAZON CRKS | PHOTO | NPS,R#5&6(189-192),1;16000,CIR |
| JUMBO LAKE | 86 | 9 | 6 | | EMPTY | DRAIN HOLES AT AMAZON AND JUMBO CRKS | PHOTO | NPS-12WRST-3-42-54&5,1:12000,CIR |
| JUMBO LAKE | 88 | 6 | 28 | | EMPTY | | PHOTO | NPS,R#1-88(1217),1:500',B&W |
| JUMBO LAKE | 89 | 8 | 10 | | EMPTY | | MAP | NPS KENNECOTT CLAIMS, 1:2400, 10'C |
| JUMBO LAKE | 89 | 8 | 10 | | EMPTY | NUMEROUS PUSH MORAINES | PHOTO | NPS,BONANZA PK#1&2,1:40000,COLOR |
| JUMBO LAKE | 90 | 0 | 0 | | ACTIVE | FILLED 19 DAYS, FLOODED PARKING LOT | USGS | WRIR#93-4078,JONES,P29, PER.COMM ELCONIN |
| JUMBO LAKE | 90 | 8 | 22 | | EMPTY | DRAIN HOLES AT AMAZON AND JUMBO CREEKS | PHOTO | NPS,R1-90(#7858-60,73-76),1:48000,COLOR |
| JUMBO LAKE | 93 | 7 | 15 | | EMPTY | | SLIDE | ROSENKRANS |
| JUMBO LAKE | 94 | 3 | 31 | | EMPTY | NO ICE | OBSERVATION | ROSENKRANS, OVERFLIGHT |
| JUMBO LAKE | 94 | 5 | 13 | 05/13/94 | FILLING | MOD. STAGE, MUDDY WATER | PHOTO | FLIGHT NOTES , ROSENKRANS |
| JUMBO LAKE | 94 | 5 | 20 | 05/20/94 | DRAINING | STAGE DECREASING @10:00-12:00 | NOTES | OBSERVATION, M. MCDONALD |
| JUMBO LAKE | 94 | 5 | 21 | 05/21/94 | DRAINING | STAGE DECREASING @19:00 | NOTES | OBSERVATION, M. MCDONALD |
| JUMBO LAKE | 94 | 5 | 23 | 05/23/95 | DRAINING | 08:30, 50% FULL, 2M WASH LINE | REPORT | ELCONIN, AERIAL OBSERVATION |
| JUMBO LAKE | 94 | 5 | 24 | 05/24/94 | DRAINING | STAGE DECREASING @18:30 | NOTES | OBSERVATION, M. MCDONALD |
| JUMBO LAKE | 94 | 5 | 25 | 05/25/94 | DRAINING | S.END DRAINED, N. END DRAINING 17:00 | NOTES | OBSERVATION, M. MCDONALD |
| JUMBO LAKE | 94 | 5 | 26 | 05/26/94 | DRAINING | S.END DRAINED, N. END PONDED 14:00 | NOTES | OBSERVATION, M. MCDONALD |
| JUMBO LAKE | 94 | 5 | 26 | 05/26/94 | EMPTY | 12:00, PONDED RESIDUAL | REPORT | ELCONIN, AERIAL OBSERVATION |
| JUMBO LAKE | 94 | 6 | 4 | 06/04/94 | FILLING | POST RELEASE, STRANDLINE VISIBLE | PHOTO | OBSERVATION, ROSENKRANS |
| JUMBO LAKE | 94 | 6 | 26 | 06/26/94 | EMPTY | 08:00, PONDED RESIDUAL GONE | REPORT | ELCONIN, AERIAL OBSERVATION |
| JUMBO LAKE | 94 | 7 | 26 | 07/26/94 | EMPTY | 19:30, CALVING ACTIVITY AT N END OF LAKE | REPORT | ELCONIN, AERIAL OBSERVATION |
| JUMBO LAKE | 94 | 7 | 29 | 07/29/94 | FILLING | FILLED BY OUTBURST EVENT 10:57AM | PHOTO | AERIAL OBSERVATION, DSR |
| JUMBO LAKE | 94 | 7 | 30 | 07/30/94 | DRAINING | DRAINING, POST RELEASE, STAGE DOWN -7M? | OBSERVATION | ROSENKRANS "NOON?" OBSERVATION, |
| JUMBO LAKE | 94 | 8 | 2 | 08/02/94 | EMPTY | 09:00, NEW STRANDLINE, WITH ICEBERGS | REPORT | ELCONIN, AERIAL OBSERVATION |
| JUMBO LAKE | 94 | 10 | 13 | 10/13/94 | EMPTY | 12:30,UNCHANGED SINCE 8/23 (7 OBSERVTNS) | REPORT | ELCONIN, AERIAL OBSERVATION |
| JUMBO LAKE | 95 | 4 | 3 | | EMPTY | | PHOTO | AERIAL OBSERVATION |
| JUMBO LAKE | 95 | 7 | 23 | | FILLING | CONTAINS OUTBURST WATER 9:00AM | PHOTO | AERIAL OBSERVATION, NOTES, ROSENKRANS |
| JUMBO LAKE | 95 | 7 | 23 | | FILLING | NO WASH LINE OBSERVED 15:00 | NOTES | OBSERVATION, ROSENKRANS |
| JUMBO LAKE | 95 | 8 | 27 | | EMPTY | NO WATER | OBSERVATION | ROSENKRANS |
| JUMBO LAKE | 95 | 9 | 25 | | EMPTY | RECEIVING H20 | NOTES | ROSENKRANS OBSERVATION |

## APPENDIX 5

Combined East and West Fork Kennicott River discharge volume from Hidden Creek Lake outburst floods.

Combined East and West Fork Kennicott River discharge volume from Hidden Creek Lake outburst floods.

| Year | Volume[1] (cubic feet) |
|---|---|
| 1986[2] | $2.40 \times 10^9$ |
| 1994 | $2.37 \times 10^9$ |
| 1995 | $1.52 \times 10^9$ |

[1] Volumes were calculated using flood hydrographs and subtracting out baseflow (Dunne and Leopold, 1978).

[2] From Friend (1988).